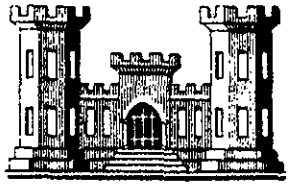
CONNECTICUT RIVER BASIN

MASTER MANUAL
OF
RESERVOIR REGULATION

APPENDIX D
WEST RIVER WATERSHED

VERMONT



U.S. Army Engineer Division, New England
Corps of Engineers Waltham, Mass.

ENGINEERING DIVISION RECORD COPY

JUNE 1965

CONNECTICUT RIVER FLOOD CONTROL

MASTER MANUAL OF RESERVOIR REGULATION

Appendix	Watershed	Reservoirs	Status
Master Manual	Connecticut River	-	Not Started
A	Ompompanoosuc River	Union Village	Completed 1950
B	Ottauquechee River	North Hartland	SOP Only
C	Black River	North Springfield	SOP Only
D	West River	Ball Mountain	Completed 1965
		Townshend	Completed 1965
E	Ashuelot River	Surry Mountain	Completed 1962
		Otter Brook	Completed 1962
F	Millers River	Birch Hill	Completed 1950
		Tully	Completed 1950
G	Chicopee River	Barre Falls	Completed 1964
		Conant Brook	Not Started
H	Westfield River	Knightville	Completed 1951
		Littleville	Not Started
I	Farmington River	Mad River	Not Started
		Colebrook River	Not Started

P R E F A C E

The West River basin comprises an area of 423 square miles and is located entirely in southern Vermont. The coordinated flood control plan for the basin, described in this manual, includes two dams and reservoirs and one local protection project.

This Appendix of the Connecticut River Master Regulation Manual and attachments include a description of the basin, statistical, climatological and flood data, project descriptions, and the standard operating procedures for reservoir regulation. The manual, in addition to setting forth a method of reservoir regulation, will serve as a reference source for future studies. Pertinent data and detailed information on the Weston local protection project are contained in Attachment I. Attachments II and III contain pertinent data of Ball Mountain and Townshend Reservoirs, respectively. Detailed regulating procedures for regulation of the reservoirs are contained in Attachment IV. Attachment V contains details of operational procedures and maintenance of hydrologic equipment.

This manual is organized in a manner that enables the reader to obtain desired general and background information in the main appendix. The attachments contain the pertinent information and detailed procedures necessary for actually regulating the protective works.

MANUAL OF RESERVOIR REGULATION
WEST RIVER BASIN
VERMONT

APPENDIX "D"

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3	Gate Operation Record

APPENDIX "D"

MANUAL OF RESERVOIR REGULATION
WEST RIVER BASIN
VERMONT

AUTHORITY AND SCOPE

1. AUTHORITY

This report is submitted pursuant to authority contained in ER 1110-2-240, dated 25 March 1963 (Reservoir Regulation) which requires that manuals of reservoir regulation for flood control, navigation or multiple-purpose reservoirs be prepared whenever storage allocated to one or more of the functions is the responsibility of the Corps of Engineers.

2. PURPOSE AND SCOPE

This manual serves as a guide and reference source for higher authority, reservoir regulation and maintenance personnel in the New England Division office, respective flood control dam operators, and for personnel who will become concerned with or responsible for regulation of the reservoirs in the West River basin. Included in this manual are:

a. A history of conditions which led to the authorization of the West River basin projects.

b. A general description of the drainage basin including topographic features and statistical data relative to population, industry and agriculture.

c. A general coverage of the hydrometeorological data for the basin which includes temperature, precipitation, snowfall, snow cover, storms, streamflow and floods.

d. The coordinated plan of improvement developed for the basin consisting of flood control dams and one local protection project.

e. Instructions for regulating the reservoir system.

f. The effectiveness of the regulation of flood control projects on the maximum recorded flood and Standard Project Flood.

HISTORY OF WEST RIVER BASIN REPORTS

3. PUBLISHED REPORTS

Flood control of the West River has been considered in the following published reports on the Connecticut River basin:

a. Survey report dated 1936 and printed in House Document No. 412, 74th Congress, presents a comprehensive plan for combined flood control and power development of the Connecticut River and its tributaries. It recommended an initial flood control plan of 10 reservoirs in Vermont and New Hampshire.

b. Survey report dated 1937 and printed in House Document No. 455, 75th Congress, proposed a revised comprehensive plan for flood control of the Connecticut River and its tributaries consisting of dikes at 7 localities and 20 reservoirs, including a reservoir on the West River at Newfane, Vermont. It recommended that the authorization for additional reservoirs be deferred, and that the authorized project be modified to provide for the protection of seven cities.

c. Second interim review report on the Connecticut River and its tributaries dated 1940 and printed in House Document No. 724, 76th Congress, recommends that modifications be made to the approved flood control plan to include local protective works at 4 additional sites and 20 reservoirs, including the Williamsville Reservoir on the West River at West Dummerston, Vermont.

d. Review of reports on flood control, Connecticut River, dated 1940 and revised in 1944 recommended the construction of 11 local protection projects and 29 reservoirs, including the Williamsville Reservoir.

e. The Flood Control Act of 1944 (Public Law 534, 78th Congress, 2nd Session) authorized the construction of 8 reservoirs on the West River instead of the Williamsville Reservoir.

f. On 20 April 1948, the Committee on Public Works of U. S.

House of Representatives resolved that, in its opinion, the modified plan for flood control with regard to the West River basin, consisting of The Island, Upper Ball Mountain and Upper Townshend Reservoirs, meets the intent of Congress as expressed in the 1944 Flood Control Act.

g. An agreement was reached in June 1950 between the Secretary of the Army, Chief of Engineers and the Vermont State Water Conservation Board for construction of 3 dams (The Island, Ball Mountain and Townshend) on the West River in lieu of the plan of 8 dams authorized by the Flood Control Act of 1944.

h. The Congress on 6 June 1953, by passage of Public Law 52, 83d Congress, granted its consent and approval to an interstate compact covering the Connecticut River Valley that had been previously ratified by the States of New Hampshire, Vermont, Massachusetts and Connecticut. The Island, Ball Mountain, and Townshend Reservoirs were among the reservoirs included in the compact. Among the principal purposes of the compact are:

(1) Resolving the tax loss problem.

(2) Assuring adequate storage capacity for impounding the waters of the Connecticut River and its tributaries in the interest of flood control.

(3) Providing a joint or common agency through which the signatory states may effectively cooperate in accomplishing the objectives of flood control and water resources utilization in the basin. The compact provides also for the creation of a commission consisting of three representatives from each of the four states with authority to enter into contracts and agreements and to make studies and investigations in cooperation with the Corps of Engineers and other Federal agencies.

i. Specific authorization for The Island, Ball Mountain and Townshend Reservoirs is contained in the Flood Control Act of 1954, which modified the plan for the West River basin to consist of the 3 reservoirs in lieu of the plan for 8 reservoirs authorized in Section 10 of the Flood Control Act of 1944.

j. Flood control of the West River is considered in Part Two, Chapter XXI of "The Resources of the New England - New York Region," dated 1957 and printed in Senate Document No. 14, 85th Congress.

It consists of a comprehensive report on the potentialities of power, land, water and related natural resources of the region. The report was prepared by the New England-New York Inter-Agency Committee and submitted to the President of the United States by the Secretary of the Army on 27 April 1956. Included among proposals for a Connecticut River basin flood control system of 26 reservoirs and 10 local protection works are 3 reservoirs on the West River at The Island, Ball Mountain and Townshend.

GENERAL DESCRIPTION

4. WEST RIVER BASIN

The West River basin as shown on Plate Nos. D-1 and D-2 is located in southern Vermont within the confines of Windham, Bennington, Rutland and Windsor counties. It has a drainage area of 423 square miles of which 278 square miles lie upstream from Townshend Dam and 172 square miles upstream from Ball Mountain Dam. The watershed is generally rectangular in shape, with a length of approximately 38 miles and a maximum width of 18 miles. Elevations vary from 220 feet msl at the mouth of the river to 460 feet at Townshend Dam, 800 feet at Ball Mountain Dam, and over 3,500 feet at several points on the watershed divide.

The general topography of the basin is hilly with steep wooded slopes characteristic of the basin from the mouth of the West River to Ball Mountain Dam. The basin upstream from Ball Mountain Dam is comparatively flat with wide valleys, but the rim of the watershed is steep and mountainous. There are few natural or artificial ponds, and in general, the drainage area is conducive to rapid runoff.

5. WEST RIVER

The West River rises in the southeastern part of Mount Holly, Vermont. From its source to Ball Mountain Dam the river flows in a southerly direction for about 23 miles and drops about 1,200 feet. The river then flows in a general southeasterly direction for about 10 miles to Townshend Dam with a drop of about 340 feet. From Townshend Dam the river continues in a southeasterly direction about 19 miles and drops about 240 feet to its confluence with the Connecticut River at Brattleboro, Vermont. The principal tributaries of the West River are Winhall River, and Ball Mountain and Whetstone Brooks. A profile of the West River is shown on Plate No. D-3.

DEVELOPMENT IN THE WEST RIVER BASIN

6. GENERAL

The 1960 population of the West River basin, based on Bureau of the Census figures, was estimated at 15,800. Population is sparse throughout the basin, the major exception being the town of Brattleboro, Vermont whose population is about 11,700. Most of the industry is confined to Brattleboro where the manufacture of non-durable goods is predominate. Industrial development in the remainder of the basin is mostly confined to wood processing. Agricultural development is not extensive except in the wider portions of the valley. Tourism is an important factor in the economic life of the basin. While there are no lakes or ponds of significant size, stream fishing, hunting and skiing are popular.

HYDROLOGY

7. CLIMATOLOGY

The West River basin has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the belt of "prevailing westerlies", and consequently is in the path of cyclonic distrubances which cross the country from the west or southwest, producing frequent weather changes. The watershed is also affected by occasional coastal storms, some of tropical origin and hurricane intensity which travel up the Atlantic seaboard. The winters are moderately severe with subzero temperatures being common. Snow cover usually persists throughout the winter, especially in the areas of higher elevation. Summers are mild with temperatures over 90° F. being infrequent. Precipitation is fairly well distributed throughout the year. Climatological stations in the vicinity of the West River basin are shown on Plate No. D-2.

8. TEMPERATURE

The climate of southern Vermont is characterized by long cold winters and relatively mild summers. Freezing temperatures are to be expected from late September to early May. The average annual temperatures in the basin vary from about 40° F. in the mountainous regions to 45° F. in the valleys. Recorded temperature extremes in

the vicinity of the basin have varied from a maximum of 102° F. to a minimum of -42° F. Monthly, mean, maximum and minimum temperatures through 1963 at Cavendish, Vermont, located about 25 miles north of Townshend Dam, and at Somerset, Vermont, located about 20 miles southwest of Townshend Dam, are shown in Table No. 1.

9. PRECIPITATION

Locations of precipitation stations in the vicinity of West River basin are shown on Plate No. D-2. The precipitation varies greatly at all stations between wet and dry years and the tendency to greater precipitation with increased elevation is very marked. Monthly, mean, maximum and minimum precipitation through 1963 at Townshend Dam and at Somerset, Vermont are summarized in Table No. 2. The record for Townshend Dam is a composite of records at Newfane, Townshend, and at the damsite.

10. SNOWFALL AND SNOW COVER

The annual, mean, maximum and minimum snowfall at Peru, South Londonderry and Wardsboro, Vermont in the West River basin are shown below:

Station (Vermont)	Period of Record (years)	Mean Snowfall (inches)	Maximum Snowfall (inches)	Minimum Snowfall (inches)
Peru	9	115.6	142.0	86.5
South Londonderry	11	87.4	123.5	53.5
Wardsboro	13	102.3	143.0	66.2

Since the initiation of a regular snow survey program by the Corps of Engineers in the winter of 1960-1961, the maximum depth of the snow cover has not exceeded 40 inches. The average maximum water content over the basin is about 9 inches and usually occurs in the latter part of March. Rapid runoff from melting of the accumulated snow cover occurs every spring, but this cause alone seldom produces damaging floods. However, the possibility of sudden thaws and moderate rains is a potential flood hazard every spring. Based on recent snow surveys, the maximum water equivalent of the snow cover for the basin during the 4-year period of record (1961-1964) was 12.2 inches in March 1963. Location of the snow courses in the West River basin is shown on Plate No. D-2.

TABLE 1

MONTHLY TEMPERATURES
(Degrees Fahrenheit)

	Cavendish, Vermont Elevation 800 feet, msl 60 Years of Record			Somerset, Vermont Elevation 2,080 feet, msl 51 Years of Record		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	18.7	65	-35	17.3	63	-31
February	19.9	63	-40	16.1	60	-39
March	29.3	82	-27	25.0	79	-31
April	42.5	93	- 2	38.0	86	- 3
May	55.1	94	17	49.8	93	16
June	63.8	100	27	58.6	98	22
July	68.1	102	33	63.2	98	30
August	65.7	99	30	60.5	96	26
September	57.9	97	18	53.6	96	17
October	47.0	89	9	52.9	90	8
November	35.6	78	-17	42.8	73	-12
December	22.4	61	-42	20.2	60	-36
ANNUAL	43.8	102	-42	40.0	98	-39

TABLE 2

MONTHLY PRECIPITATION RECORD
(In Inches)

	Townshend Dam, Vermont Elevation 800 feet, msl 41 Years of Record*			Somerset, Vermont Elevation 2,080 feet, msl 51 Years of Record		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	3.24	7.00	0.67	4.61	8.01	1.29
February	2.88	5.40	0.65	3.72	6.93	1.65
March	3.30	10.96	0.68	4.81	10.49	0.45
April	3.76	7.80	0.43	4.66	10.42	0.43
May	3.64	8.54	0.80	4.52	8.02	1.35
June	3.52	7.81	0.79	4.64	8.15	0.91
July	3.84	11.70	0.95	4.27	12.19	0.88
August	3.04	9.20	0.90	3.88	11.26	0.53
September	3.50	10.70	0.47	4.88	11.79	0.91
October	3.46	10.74	0.60	3.93	12.00	0.60
November	4.25	10.03	0.94	4.91	14.54	0.91
December	3.12	6.90	0.40	4.66	8.98	1.19
ANNUAL	41.55**	66.40	32.87	53.30	64.78	41.50

* Precipitation values based on composite of records from Newfane, Townshend and Townshend Dam.

** Average based on records from 1921-1955 and 1958-1963 inclusive.

11. STORMS

The West River basin has experienced storms of four general types, namely:

a. Extratropical continental storms which move across the basin under the influence of the "prevailing westerlies".

b. Extratropical maritime storms which originate and move northward along the Atlantic coast.

c. Storms of tropical origin some of which attain hurricane magnitude.

d. Thunderstorms produced by local convective activity or by more general frontal activity.

Hurricane type storms generally arrive in late summer and fall. The hurricane of September 1938 which produced the greatest flood of record in the West River watershed was of this type. This storm and the storms of November 1927, December 1948 and March 1936 caused the four greatest floods of record.

12. STREAMFLOW

The U. S. Geological Survey has gaging stations on Flood Brook (DA = 9.25 square miles) near Londonderry, Vermont on the West River at Jamaica, Vermont about 2.6 miles downstream from Ball Mountain dam and Newfane, Vermont about 6.3 miles downstream from Townshend dam. The drainage area above Jamaica is 179 square miles and above Newfane, 308 square miles. Locations are shown on Plate No. D-2.

13. RUNOFF

The average annual runoff for the West River basin, adjusted for upstream storage and regulation is 1.99 cfs per square mile based on 39 years of record (September 1919 to September 1923 and October 1928 to September 1963) for the USGS gaging station at Newfane. The rate of runoff is equivalent to 27.5 inches per year which is about 0.6 of the average annual precipitation over the basin.

14. FLOODS OF RECORD

a. Historic floods. Prior to the establishment of the Newfane

gaging station, several floods occurred on the West River that were sufficiently important to have been mentioned in the newspapers of the time and in histories of the area. Largely because there were no important settlements along the river, no record of flood stages or damages from these floods has been found. The known dates of such floods are:

7-8	Jan	1770	24-25	July	1830
20-22	Oct	1785	8-9	Jan	1841
18-22	Mar	1801	27 Apr	to	
10-13	Feb	1824	-1	May	1854
24-25	Mar	1826	18-19	Apr	1862
3-5	Sept	1828	3-5	Oct	1869

b. Recent floods. In recent years floods of major proportions have occurred as follows: November 1927, March 1936 (two floods), September 1938, and December 1948. A brief description of each flood is given in the following paragraphs. Discharge hydrographs for the March 1936 and September 1938 floods are shown on Plate Nos. D-4 and D-5.

c. November 1927 flood. After the Newfane gaging station was re-established in October 1938, it was estimated from a known high water mark that the maximum rate of discharge of the November 1927 flood was 45,000 cfs at Newfane.

d. Floods of March 1936. A peak flow of 39,000 cfs with a stage of 19.3 feet was measured at Newfane on 18 March 1936. This was the second and larger of two closely related flood peaks which occurred during the month, a peak of 12,200 cfs with a stage of 11.3 feet being observed on 13 March. Both were caused by a combination of rainfall and melting snow. The total rainfall for the period 9-22 March inclusive, as measured at the Newfane station, amounted to 9.3 inches. The snow cover at the beginning of this period had an estimated water equivalent of 7.3 inches over the basin. As estimated by the U. S. Geological Survey, the first flood had a volume of 2.9 inches and the second 7.4 inches.

e. September 1938 flood. The highest known rate of discharge at Newfane is that of 21 September 1938 with an estimated peak of 52,300 cfs and a stage of 22.81 feet. This flood resulted from 7.7 inches of

rainfall on the watershed from 17-21 September inclusive. The volume of flood runoff was estimated to be 5.0 inches at Newfane.

f. December 1948 flood. The peak of the 31 December 1948 flood was the third highest known rate of discharge at Newfane with a stage of 19.46 feet and an estimated peak discharge of 44,000 cfs, and the highest during the short period of record at Jamaica (29,500 cfs). Unfortunately the gaging station at Newfane was out of order during most of this flood. At Jamaica, however, 5.6 inches of runoff resulted from about 7 inches of rainfall including some snowmelt. This flood was followed by another rise on 6 January 1949 with peak discharges of 8,350 cfs at Newfane and 3,700 cfs at Jamaica.

15. FLOOD PROFILES

High water profiles on the West River were determined from field surveys after the floods of November 1927, March 1936 and September 1938. Profiles for these floods are shown on Plate No. D-3.

16. FLOOD FREQUENCIES

The frequency or percent chance of occurrence of discharges in the West River basin were determined for the U. S. Geological Survey gaging stations at Jamaica and Newfane. Frequency analyses were made in accordance with procedures described in ER 1110-2-1450, "Hydrologic Frequency Estimates," dated 10 October 1962. Discharge-frequency data for the selected locations are shown on Table No. 3.

17. ANALYSIS OF FLOODS

The major floods of record were analyzed to determine the hydrologic development of floods in the West River basin. The hydraulic characteristics and potentialities of tributary areas were appraised to find the relative timing and discharge contributions at damage centers along the West River as well as the major damage centers on the Connecticut River. The analysis of record floods in the West River basin resulted in the following conclusions:

a. Floods may occur on the West River at any time of the year.

b. Due to the absence of lakes or ponds of significant capacity, natural storage does not appreciably lower flood peaks.

c. Steep slopes at the rim of the basin and near the river itself below the Ball Mountain damsite produce rapid runoff.

TABLE 3

WEST RIVER BASIN
NATURAL PEAK DISCHARGE FREQUENCY DATA
(Discharge in cfs)

Expected Probability Percent Chance	Years	West River at Newfane, Vermont	West River at Jamaica, Vermont
.50	200	76,000	52,000
1.00	100	59,500	39,500
2.0	50	46,500	30,000
4.0	25	36,500	22,500
5.0	20	33,500	21,000
10.0	10	25,500	15,500
20.0	5	19,000	11,200
50.0	2.0	12,000	6,900
60.0	1.7	10,500	6,100
70.0	1.4	9,400	5,500
80.0	1.25	8,200	5,000
90.0	1.13	7,000	4,600
95.0	1.06	6,200	4,300
99.0	1.02	5,300	4,000
99.9	1.+	4,600	3,800

d. The relative peak timing of the flood crests at the principal control points in the West and Connecticut River basins is shown in Table No. 4.

e. The contribution of the West River to Connecticut River floods depends primarily on the origin of the flood and the location of the storm center. In general, the West River flows will occur before Connecticut River floods originating in the more northerly sections of the basin, and after those occurring in southern Massachusetts and Connecticut. Contributions of the West River to the floods of March 1936, September 1938 and December 1948 are shown in Table No. 5.

18. STANDARD PROJECT FLOOD

A standard project flood for West River at Townshend was developed for Design Memorandum No. 1, Hydrology and Hydraulic Design, Townshend Dam and Reservoir, dated June 1956, as a demonstration flood to measure the effectiveness of Ball Mountain and Townshend Reservoirs. Rainfall for the standard project storm was determined in accordance with Engineer Bulletin for Civil Works, No. 52-8, with the storm being centered over the area between Ball Mountain and Townshend Reservoirs. For the area upstream from Ball Mountain Dam, the average rainfall was 8.9 inches and the runoff was 6.6 inches. For the area between Ball Mountain and Townshend Dams, the average rainfall was 11.7 inches and the runoff 9.2 inches. Hydrographs were obtained by applying the rainfall to the unit hydrographs developed for the spillway design flood. The reservoirs did not have sufficient capacity to store all of the runoff, but at Townshend Dam the natural flow of 113,000 cfs would be reduced by the two reservoirs to an outflow of 26,000 cfs. The regulation of the flood is shown on Plate No. D-6.

19. FLOOD DAMAGES

Ball Mountain and Townshend Reservoirs are regulated to provide flood protection for downstream communities along the West River. They are also regulated with a comprehensive system of reservoirs to reduce flood stages along the main stem of the Connecticut River. Since their construction, Ball Mountain and Townshend Reservoirs have prevented damages estimated at $1 million and $570,000, respectively. With a recurrence of the record Connecticut River flood of March 1936, the reservoirs would prevent dollar damages as follows:

TABLE 4

RELATIVE PEAK TIMING
FLOOD CRESTS
WEST RIVER AND CONNECTICUT RIVER BASINS

Location	River Mile	Drainage Area (sq.mi.)	Time of Peak(1) March 1936	Sept. 1938	Dec. 1948
West River					
Ball Mountain Dam	29.0(2)	172	-10	-7	-7
Jamaica	26.4(2)	179	-10	-7	-7
Townshend Dam	19.5(2)	278	-9	-6	-6
Newfane	12.7(2)	308	-8	-5	-5
Mouth - West River	149.2(3)	423	0	0	0
Connecticut River					
North Walpole, N. H.	173.6(3)	5,493	+9	+8	-1
Vernon	141.8(3)	6,266	+12	+14	+5
Montague City, Mass.	119.1(3)	7,865	+15	+20	+14

(1) Time in hours, before (-) and after (+) peak of West River at mouth

(2) Above mouth of West River

(3) Above mouth of Connecticut River

TABLE 5

WEST RIVER CONTRIBUTIONS TO
CONNECTICUT RIVER PEAK DISCHARGES

Flood	Item	Discharge in CFS		
		West River at Mouth (DA - 423 sq.mi.)	Connecticut River	
			Vernon (DA - 6,266 sq.mi.)	Montague City (DA - 7,865 sq.mi.)
Mar 1936	Peak Flow	43,600	176,000	236,000
	Contribution of West River	-	24,350	27,700
	Percent	-	13.8	11.7
Sept 1938	Peak Flow	44,300	132,500	194,800
	Contribution of West River	-	39,330	29,330
	Percent	-	29.7	15.1
Dec 1948	Peak Flow	37,600	88,600	139,000
	Contribution of West River	-	30,370	27,000
	Percent	-	34.3	19.4

Project	Estimated Flood Damage Prevention in Recurrence of March 1936 Flood
Ball Mountain Dam and Reservoir	$10,900,000
Townshend Dam and Reservoir	$ 7,400,000

The data from damage zones below Townshend Dam on the West River basin have been combined into a single curve and correlated with stages at the index station at Newfane where river stage information can be readily obtained during flood periods. The curves shown on Plate No. D-7 assume no contribution from Townshend Dam and are intended to provide approximate damage figures for the lower West River only. Additional detailed surveys following a flood event would supplement this data as required.

FLOOD CONTROL PLAN

20. GENERAL

The coordinated flood control plan for the West River basin consists of two reservoirs and one local protection project. The reservoirs are operated primarily to desynchronize floodflows of the West River from floodflows on the Connecticut River. The operation of the reservoirs are coordinated with other reservoirs in the Connecticut River basin to obtain maximum reduction in overall flood damages. A brief description of the flood control reservoir projects and local protection project in the West River basin is given in the following paragraphs. The locations of the projects are shown on Plate No. D-2. Detailed information of the local protection project and the reservoirs is presented in Attachments I, II, and III.

21. RESERVOIRS

a. The Island Dam and Reservoir. The Island Dam, although an authorized project, is currently in a "deferred for restudy" category. The restudy will be accomplished in the Connecticut River Comprehensive Basin Study. The dam, controlling runoff from a

watershed of 40 square miles, would be located about 11 miles upstream of Ball Mountain Dam. The reservoir would have a storage capacity of 19,400 acre-feet, equivalent to 9 inches of runoff.

b. Ball Mountain Dam and Reservoir. Ball Mountain Dam and Reservoir, completed in October 1961, is situated on the West River in the Townships of Jamaica and Londonderry, Windham County, Vermont. The earth and rock fill dam with a top elevation of 1052.0 feet msl is 915 feet long and has a maximum height of 265 feet above the streambed. The concrete chute spillway with a crest length of 235 feet and a top elevation of 1017.0 feet msl is located on the right abutment of the dam. The outlet works are located in the right abutment and consist of an inlet channel, intake tower, a concrete lined tunnel in rock under the dam and an outlet channel. The reservoir flood control storage capacity of 54,600 acre-feet at spillway crest is equivalent to 6.0 inches of runoff from the drainage area of 172 square miles.

c. Townshend Dam and Reservoir. Townshend Dam and Reservoir, completed in June 1961, is situated on the West River in the Townships of Townshend, Windham County, Vermont. The rolled earth and rock fill dam with a top elevation of 583 feet msl is 1,700 feet long and has a maximum height of 133 feet above the streambed. The side channel spillway with a crest length of 439 feet and a top elevation of 553 feet msl is located on the left abutment of the dam. The outlet works through the dam consist of an inlet channel, intake structure, reinforced concrete horseshoe conduit and an outlet channel. The reservoir flood control capacity of 33,900 acre-feet at spillway crest is equivalent to 6.0 inches of runoff from the drainage area of 106 square miles below Ball Mountain Dam. A conservation pool is maintained at elevation 478 feet msl.

22. LOCAL PROTECTION PROJECT

Weston is located in the south central portion of Vermont about 21 miles northwest of Bellows Falls. The project construction extends from the Vermont Guild Mill to about 1,700 feet downstream. The protective works completed in July 1957 consist of channel improvement, a small dike and a stoplog structure.

RESERVOIR REGULATION

23. ORGANIZATION

The Reservoir Regulation Section is responsible for regulation of floodwater at the flood control reservoirs in the New England area. In the New England Division the Hydrology & Hydraulics Section of the Engineering Division also functions as the Reservoir Regulation Section. In addition to its regular flood control duties, the Reservoir Regulation Section is also responsible for (a) monthly reports on reservoir regulations; (b) continuing studies of regulation procedures; (c) analyses of actual flood operations; (d) the establishment of data gathering and reporting network; (e) maintenance of hydrologic equipment; and (f) the training of personnel. The supervision of routine operations and maintenance activities come under the jurisdiction of the Maintenance Branch of the Operations Division. An organization chart for reservoir regulation in the New England Division is shown on Plate No. D-8.

The Reservoir Regulation Section is subdivided into basin units, each responsible for receiving routine hydrometeorological reports and directing reservoir regulation within an assigned river basin. Each unit consists of a regulator in charge of the overall operation in the Connecticut River basin, and project regulators who receive reports and issue regulation instructions to individual dams either from NED headquarters during normal work-hours or from their homes during nonwork-hours.

Whenever emergency conditions so require, the Reservoir Regulation Section staffs NED headquarters and the regulation units are organized to assure 24-hour operation as long as the emergency exists.

24. INSTRUCTIONS TO OPERATORS

All instructions to operators for regulation of the flood control reservoirs are given directly by the Reservoir Regulation Section with advisories forwarded to the Operations Division. When a flood control dam operator is unable to communicate with the Reservoir Regulation Section and the circumstances require immediate action, the operator has full authority and responsibility to promptly regulate the reservoir in accordance with procedures described in Attachment IV.

25. COMMUNICATIONS

All communications between the flood control dam operator and the Reservoir Regulation Section are made via the NED radio network during normal work-hours or when NED headquarters are otherwise manned. Whenever the radio system is inoperative, communications will be made by telephone. During the nonwork-hours, reports and regulation instructions are issued by telephone to or from the homes of the Reservoir Regulation Section personnel. The Townshend operator will relay all information from both dams to the basin regulator whenever circumstances warrant a telephone report. In his absence the Ball Mountain operator will relay the pertinent information. A telephone directory is maintained and issued by the Reservoir Regulation Section for its specific use during flood operations. In the event of failure of the NED radio network and telephone service, emergency communications will be attempted through State Police and Civil Defense radio facilities.

26. PRECIPITATION REPORTING NETWORK

In the West River basin, reports of precipitation data are primarily used for the purpose of alerting regulation personnel and to provide a basis for forecasting the severity of a storm. The River Forecast Center at Windsor Locks, Connecticut receives reports from USWB precipitation stations in the West River basin which are also made available to the RRS. Precipitation reports by the USWB are supplemented by precipitation data furnished by the Ball Mountain and Townshend operators. These operators receive reports from Peru, South Londonderry, Wardsboro and Newfane as well as their respective dams. The locations of the USWB and NED precipitation networks are shown on Plate No. D-2.

27. RIVER REPORTING NETWORK

The streamflow network for the West River basin consists of two USGS gaging stations on the West River. The stations located at Jamaica and Newfane, Vermont are shown on Plate No. D-2 and are described in the following paragraphs:

a. West River at Jamaica, Vermont. The USGS gaging station at Jamaica is located on the left bank of the West River 0.4 mile upstream of Ball Mountain Brook and 2.5 miles downstream from Ball Mountain Reservoir. The gage, recording runoff from 179 of the total 423 square mile watershed area of the West River basin, has been in operation since October 1946.

b. West River at Newfane, Vermont. The USGS gage at Newfane has been in operation from September 1919 to September 1923 and October 1928 to the present. The gaging station is located on the right bank of the West River about 1 mile northeast of Newfane and records discharges from a drainage area of 308 square miles. The installation of a Telemark transmitter at the station makes it possible to obtain river stage data via telephone.

28. WEATHER AND RIVER FORECASTS

a. Precipitation forecasts. In addition to the normal periodic weather forecasts, quantitative precipitation forecasts prepared by the U. S. Weather Bureau are received daily over the Massachusetts Weather Teletype Network by the Reservoir Regulation Section. Supplemental weather information and forecasts are made available upon request to the U. S. Weather Bureau offices at Boston, Massachusetts and Windsor Locks, Connecticut.

b. USWB river forecasts. The USWB does not forecast floods on the West River; however the U. S. Weather Bureau River Forecast Center at Windsor Locks, Connecticut is responsible for preparing and disseminating flood forecasts for the Connecticut River basin. The River Forecast Center at Windsor Locks also prepares and transmits by teletype to the Reservoir Regulation Section biweekly headwater advisory forecasts, indicating the amount of 12-hour rainfall necessary to produce flood conditions for the Passumpsic River at Passumpsic, Vermont; the White River at West Hartford, Vermont; the Chicopee River at Indian Orchard, Massachusetts; the Westfield River at Westfield, Massachusetts; the Farmington River at Riverton, Connecticut; and the Park River in Hartford, Connecticut, all in the Connecticut River basin.

c. USCE flood forecasts. Methods for making flood peak forecasts have been developed for Corps of Engineers use only. Curves of rainfall at Newfane versus flood peaks at West Dummerston on the West River have been prepared from limited available information on past flood records. These curves will be checked with future data and modified if necessary to improve the correlation. The curves are shown in Attachment IV.

29. REPORTS

a. Weekly reports. The flood control dam operator makes a routine report by radio or telephone to the Reservoir Regulation Section at 0815 each Friday. This report insures continuous contact

between the operating personnel and the Reservoir Regulation Section and also serves as a communications test. The report includes the preceding 24-hour precipitation and current weather data, reservoir stage and regulation data, river conditions at index stations, and other miscellaneous data. A sample of the completed form is shown on Sheet No. 1.

b. Alerting reports. An alerting report is promptly made and includes pertinent data that is readily available and a general appraisal of local conditions although complete data from all the rainfall and flood-warning stations may not be available. Whenever any of the following conditions occur during work-hours, the flood control dam operators at Ball Mountain and Townshend will immediately notify the Reservoir Regulation Section.

(1) Precipitation. Occurrence of one inch (1") during a 24-hour period at any precipitation station within the network.

(2) Reservoir stage. Whenever a rising stage of 25 and 27 feet is reached at Ball Mountain and Townshend Reservoirs, respectively.

(3) River stage. Whenever the river stage at the Newfane gage reaches 7 feet and is rising.

(4) Unusual conditions. Any unusual local conditions such as difficulty with gates, ice, excessive debris, etc. Whenever conditions warrant an alerting report during nonworking hours, available basin data is compiled by the Townshend operator who will relay the information via telephone to the designated RRS regulator. In the absence of the Townshend operator, the Ball Mountain operator will relay the pertinent data.

c. Flood reports. Supplemental radio or telephone reports (Second Alert) are made to the RRS by the flood control dam operator if heavy rainfall continues or if it appears that flood conditions might develop in the basin as the result of melting snow, heavy localized rainfall, dam failures, etc. The time and frequency of these reports are dependent upon the severity of conditions and specific instructions from the Reservoir Regulation Section. Flood reports are transmitted at minimum 3-hour intervals. Sheet No. 2 shows a typical log of reports which indicates the data to be included in reports by the flood control dam operator during flood periods. Insofar as practicable, the following information is included in the flood report to the Reservoir Regulation Section:

(1) Precipitation at dam. The total amount of precipitation which has fallen up to the time of reporting and several intermediate amounts with the times of observation.

(2) Reservoir stage. The pool stage at the time of reporting and several previous readings with the corresponding times to determine the rate of rise of the pool and to define the inflow hydrograph. (Accurate simultaneous readings of both stage and time are very essential to facilitate computations made by the RRS).

(3) Gate positions. Gate openings and discharges at the time of reporting and at the beginning of the storm.

(4) Precipitation reports from observers. Precipitation reports received from cooperative observers.

(5) West River stage. River stage at time of reporting at Newfane, Vermont.

(6) Snow cover. General snow cover which may affect runoff conditions throughout the basin.

(7) Miscellaneous data. Any other information which might be pertinent.

d. Special reports. A special report is submitted whenever unusual circumstances occur during a flood or if a special report is requested by the RRS. The report may be written in longhand and should describe the subjects outlined below if appropriate.

(1) Observations at dam. The flood control dam operator makes general observations of conditions occurring at the outlet works as listed below. The observations are entered in the log book at the dam. If possible, photographs are taken of any unusual conditions noting the date, time, the reservoir gage heights and position of the gates.

(a) Intake and portal. Extent and action of eddies and waves in the vicinity of the conduit intakes and portals.

(b) Outlet and spillway discharge channels. Extent and action of turbulence or eddies downstream of the spillway and outlet works.

(c) Ice and debris. Effect on the flow through the gates due to an accumulation of ice or debris at the intake.

(d) Gates. The pool elevation and position of the gates at which vibration may develop.

(e) Other. Any other unusual hydraulic phenomena that may occur.

(2) Observations at control points. During periods of reservoir regulation, particularly while emptying the reservoir, reconnaissance of the river is made by the flood control dam operator to obtain further data on the safe channel capacity of the West River through principal damage areas. Critical stages at damage points are correlated with the concurrent stage at the nearest gaging station to obtain the corresponding discharge.

30. MAINTENANCE OF LOG

All reports, instructions, records of unusual circumstances at the dam, and information pertinent to regulation of the reservoir is entered in the logs. A log is maintained by both the flood control dam operator and the Reservoir Regulation Section.

31. GATE OPERATION RECORD

All gate operations are carefully noted on NED Form 90, a sample of which is shown on Sheet No. 3, and submitted monthly with recorder charts of reservoir stages. All operations are noted regardless of the duration of the change in gate position. The report includes date and time of day, gate opening, reservoir gage height, and reason for operation.

32. SPECIAL ADVISORIES

In accordance with regulations set forth in EM 500-1-1, Emergency Flood Control Activities, special advisories on flood potential and the progress of all threatening storms are submitted by RRS to the Division Engineer; Chief, Engineering Division; Chief, Planning and Reports Branch; Emergency Operations Planning Office and to the Operations Division.

33. HYDROLOGIC EQUIPMENT

Operational procedures and maintenance of the hydrologic equipment for Ball Mountain and Townshend Dams consisting of the precipitation gage, thermometer, reservoir stage recorder, telephone transmitter (telemark - located at Newfane), and snow sampling sets, are contained in Attachment V.

34. SNOW SURVEYS

Snow courses have been established at selected locations within the reservoir watershed and are shown on Plate No. D-2. Weekly surveys are made by the flood control dam operator during the winter and early spring to determine the depth of snow and its equivalent water content. The dates for surveys are determined each year by the Reservoir Regulation Section so as to correspond with the publication of the monthly bulletin of the U. S. Geological Survey.

35. ABSENCE FROM DAM

The Reservoir Regulation Section is notified whenever the flood control dam operator expects to be absent overnight from the dam.

36. RESERVOIR REGULATION - NORMAL PERIODS

a. Nonfreezing season.

(1) Ball Mountain Reservoir. All 3 gates will be maintained at 3-foot openings.

(2) Townshend Reservoir. A permanent pool will be maintained for recreational uses at a stage of about 22 feet. Normally, the 2 outside gates will be closed and the middle gate fully opened. During minor rises, the 2 outside gates will be operated according to a schedule to minimize pool stage fluctuation as described in Attachment IV.

b. Freezing season. Commencing about 1 December the gates will be throttled in order to maintain a winter pool of 13 to 20 feet at Ball Mountain Reservoir, and 23 to 25 at Townshend Reservoir. The pools will be developed gradually with some water being released continually.

c. Thawing season. About 15 March, upon instructions from the RRS, the winter pools will be drawn down to normal levels (see paragraph 36a).

d. Minimum discharge. A minimum discharge of approximately 10 cfs will be discharged at all times to maintain fish life in the river below the dams.

37. RESERVOIR REGULATION - FLOOD PERIODS

Flood regulation of Ball Mountain and Townshend Reservoirs are initiated for river stages on the West and Connecticut Rivers and also for rainfall over the basin. The regulation is considered in three phases during the course of a flood: Phase I, the initial regulation during the development of the flood; Phase II, regulation during the flood periods; and Phase III, emptying the reservoir following the downstream recession of the flood.

Phase I is the most critical stage since it is necessary to collect rainfall and discharge data and to promptly recognize and appraise the development and magnitude of the flood in a short period of time. Phase I terminates when gates at the dams are operated to restrict the reservoir outflows.

Phase II is a continuation of regulation. Further gate operations may be necessary in order to maintain nondamaging flows in downstream river channels. If the gates are closed, they remain in this position until Phase III, when the stored waters are released. Major activity during Phase II is the collection of hydrologic and hydraulic data.

Phase III, following the recession of the flood, consists of emptying the reservoirs as rapidly as possible without exceeding safe channel capacities at downstream damage areas. Secondary river rises during Phase III due to either additional rainfall or snowmelt may result in reverting back to Phase I regulation procedures.

Further details of the regulation procedures are contained in Attachment IV.

38. RESERVOIR REGULATION - WHITE WATER CANOE RACES

White water canoe races are conducted on a 3-day week-end each year on the West River below Ball Mountain Dam. The races are

conducted not later than the middle of May. To assure ideal racing conditions, approximately 2,500 acre-feet of runoff are stored in the reservoir and released at a prescribed rate to satisfy the racing schedule and the available storage. Prior to the races, 600 acre-feet of storage is emptied from Townshend Reservoir to compensate for the storage at Ball Mountain.

Details of regulation to store and release basin runoff for the canoe races are contained in Attachment IV.

39. COOPERATION WITH DOWNSTREAM WATER USERS

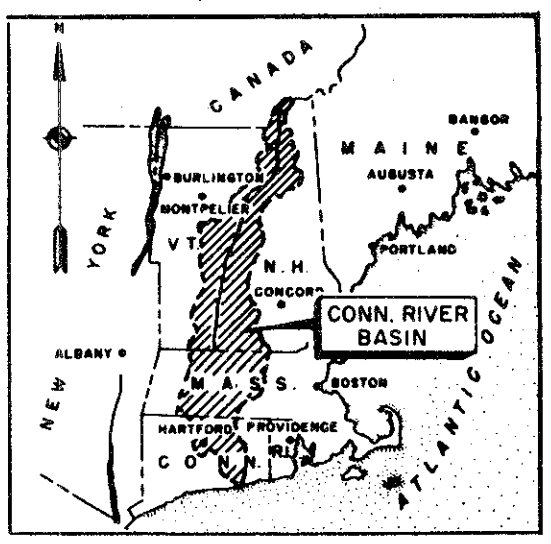
It is the policy of the Corps of Engineers to cooperate whenever possible with downstream water users and other interested parties and agencies. The flood control dam operator may be requested by downstream users to deviate from normal regulations for short periods of time. Whenever a request for such modification is received, the operator will ascertain the validity of the request and obtain assurances from other downstream water users that they would be agreeable to the proposed operations. The operator then will relay the information to the Reservoir Regulation Section and request instructions.

40. EXAMPLES OF RESERVOIR REGULATION

The maximum recorded flood on the West River occurred in September 1938. The regulation of this flood at Ball Mountain and Townshend Reservoirs and the effect of the Connecticut River basin reservoirs at Vernon and Montague City are shown on Plate No. D-5. Plate No. D-4 shows the regulation of the March 1936 flood, and the natural and modified flows at Vernon and Montague City.

41. FUTURE STUDIES

Post flood studies will be made of each period of reservoir regulation to determine the efficiency of the communication and reporting networks and the applicability of the regulation guides, including stage-discharge relationships, discharge correlations, and flood reductions at damage centers.



LOCATION MAP

SCALE IN MILES

40 0 40 80

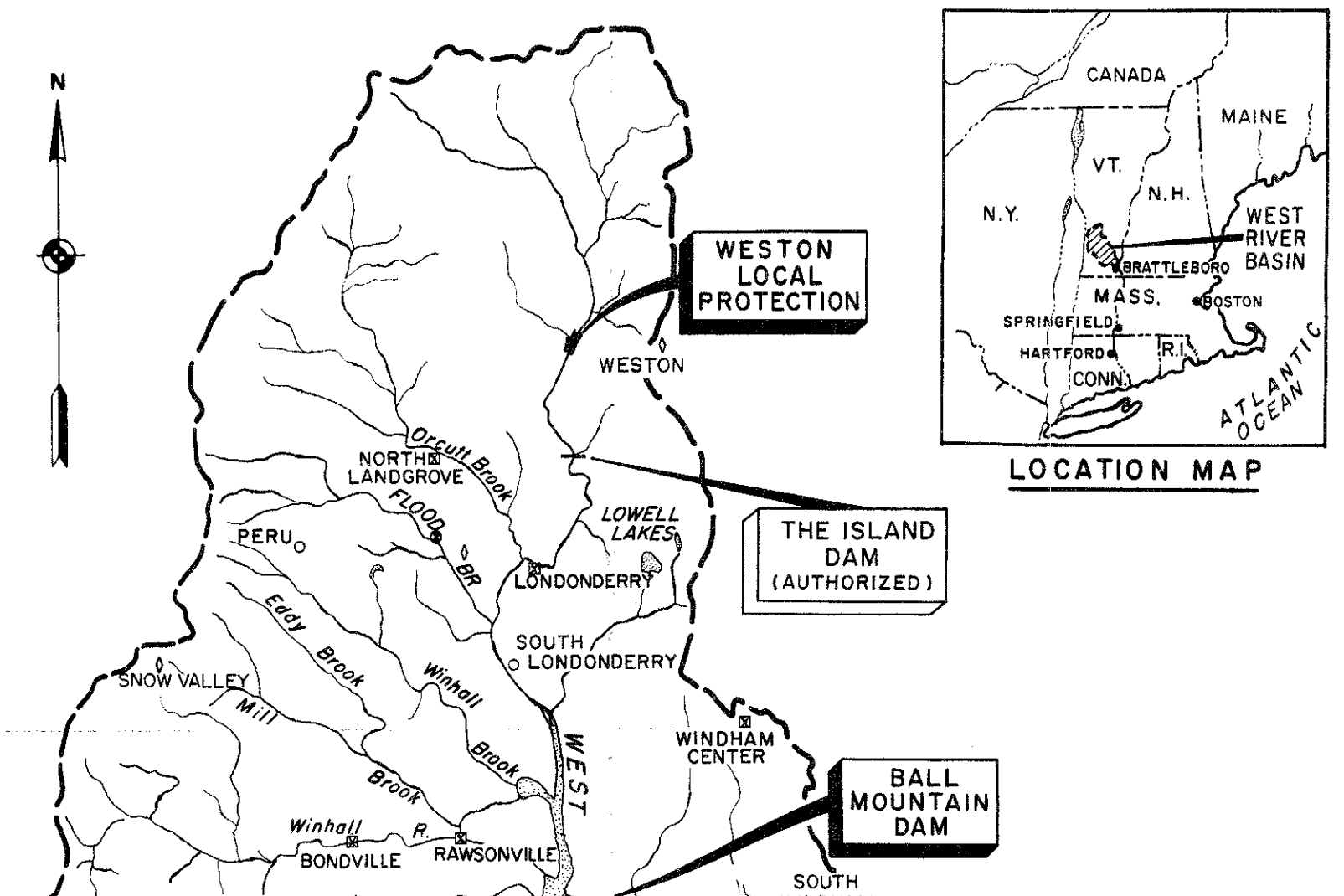
CONNECTICUT RIVER BASIN

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

SCALE IN MILES

0 4 8 16

PLATE NO. D-1



LOCATION MAP

STATION LEGEND

- ○ Precipitation, Non-Recording
- ● Precipitation, Recording
- ⊠ Towns
- ⊛ River Gaging Station
- ◊ Snow Survey Station
- ▭ Completed Projects

BASIN MAP

SCALE IN MILES

2 0 1 2 3

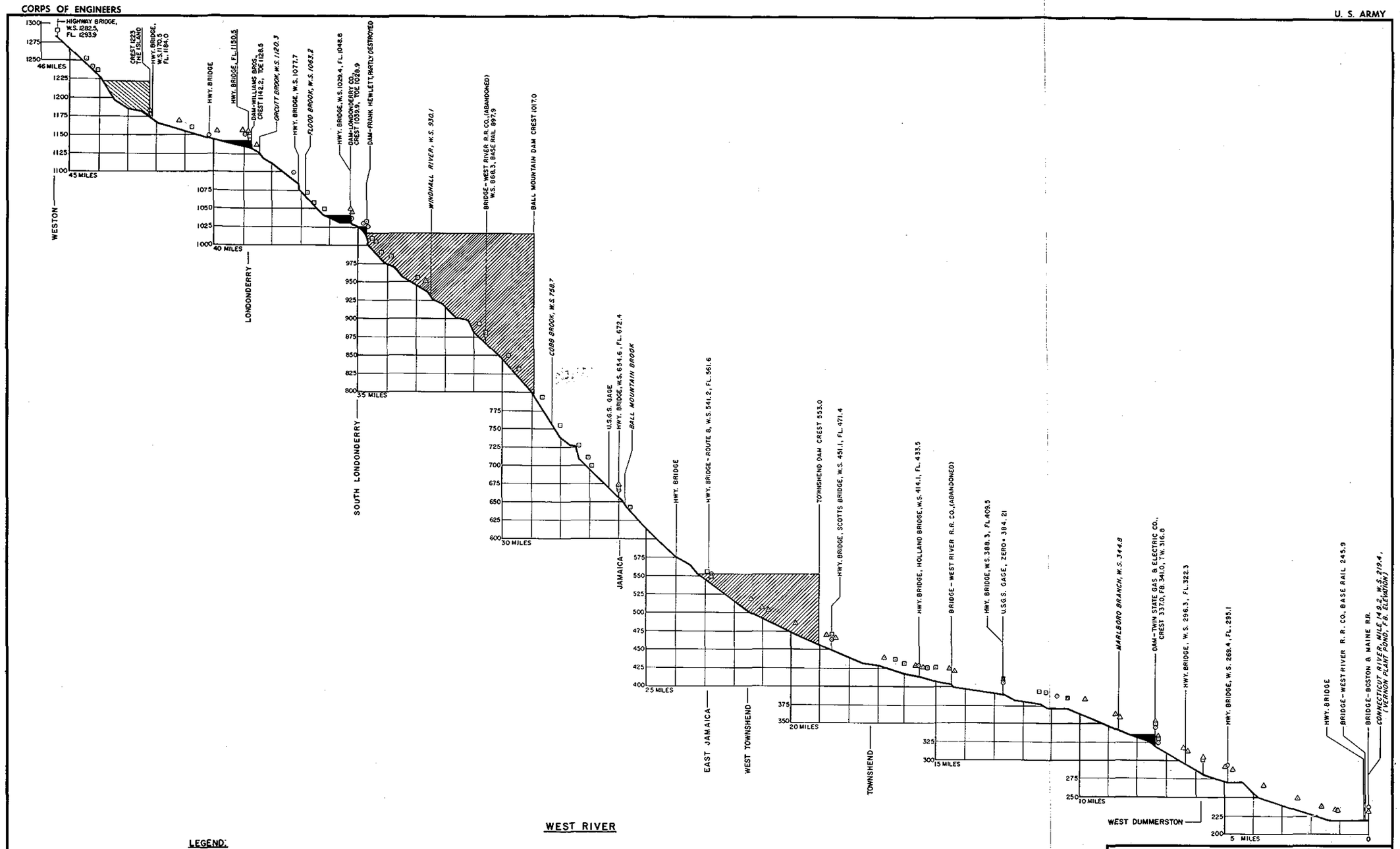
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER BASIN
BASIN MAP
WEST RIVER VERMONT

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

PLATE NO. D-2

CORPS OF ENGINEERS

U. S. ARMY



WEST RIVER

LEGEND:

- ◥ - EXISTING DEVELOPMENT
- ◭ - FLOOD CONTROL DEVELOPMENT
- ◥ - PROPOSED FLOOD CONTROL DEVELOPMENT
- △ -- INDICATES HIGH WATER MARKS OF SEPT. 1938.
- ○ -- INDICATES HIGH WATER MARKS OF MARCH 1936.
- □ -- INDICATES HIGH WATER MARKS OF NOV. 1927.
- FL -- FLOOR.
- FB -- FLASHBOARD.
- W.S. WATER SURFACE
- T.W. TAIL WATER

NOTES:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL DATUM.
DISTANCES IN MILES FROM CONNECTICUT RIVER.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY G.H.D.	CK. BY

PRO. OF ENGINEER

CHIEF, SECTION

SUBMITTED BY

CHIEF, PLANN & RPTS. BRANCH

CONNECTICUT RIVER FLOOD CONTROL

PROFILE
WEST RIVER

WEST RIVER, VERMONT

APPROVED DATE

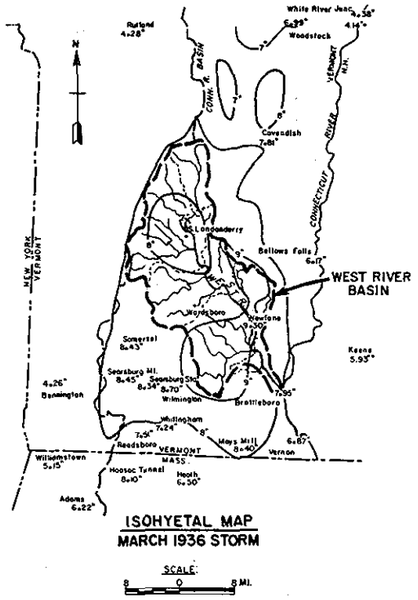
CHIEF, ENGINEERING DIVISION

SCALE:

DRAWING NUMBER

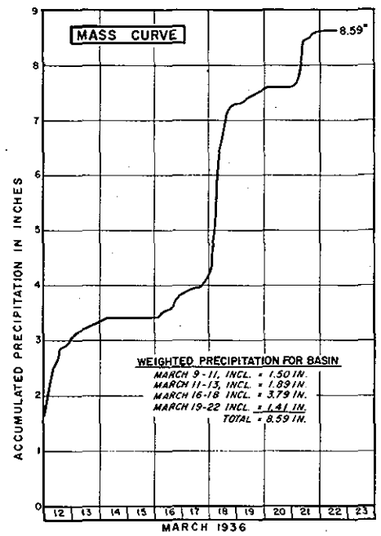
SHEET

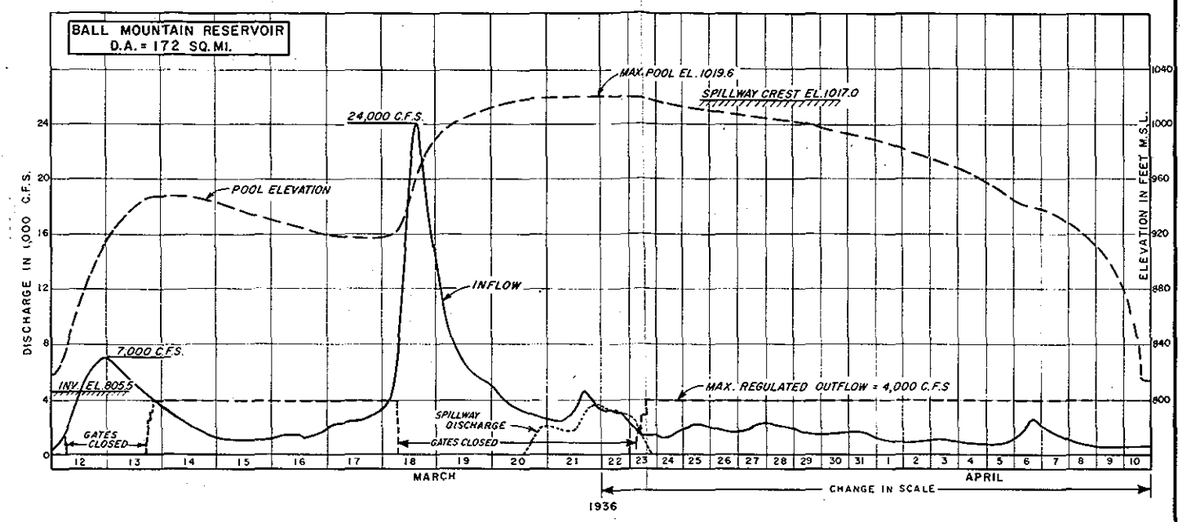
PLATE NO. D-3

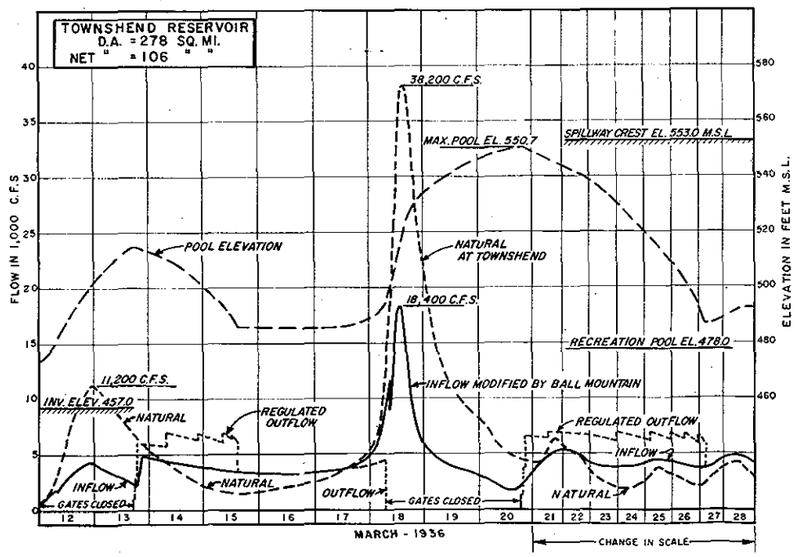


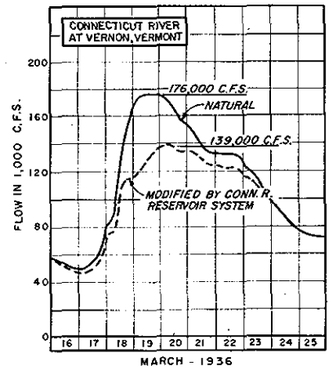
ISOHYETAL MAP
MARCH 1936 STORM

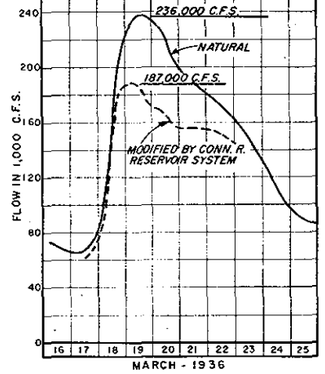
SCALE: 8 0 8 MI.











REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CK. BY
	G.H.D.	

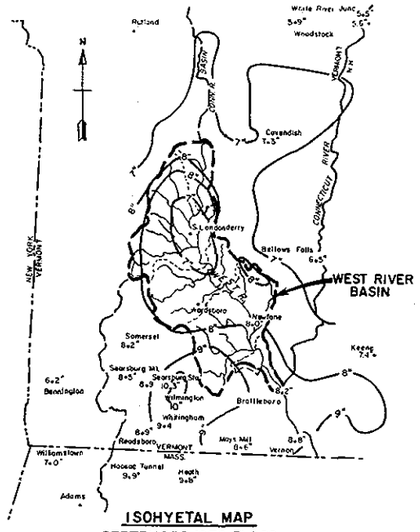
PROJECT ENGINEER
CHIEF, R.D.& R. SECTION
SUBMITTED BY
CHIEF, PLANS & SPEC'S BRANCH
APPROVED
CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER BASIN
MARCH 1936 FLOOD
WEST RIVER, VERMONT

APPROVED DATE
COL., C.E. DEPUTY DIVISION ENGINEER

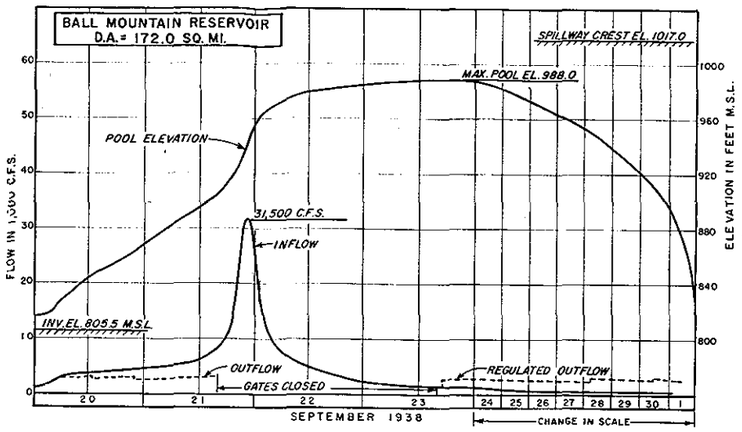
SCALE
SPEC. NO CIV ENG.-19-016-
DRAWING NUMBER
SHEET

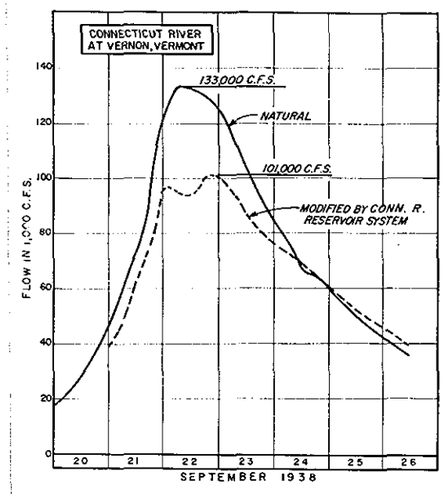
PLATE NO. D-4

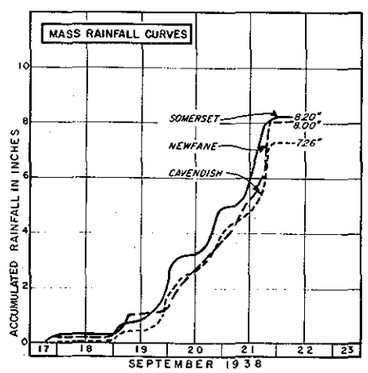


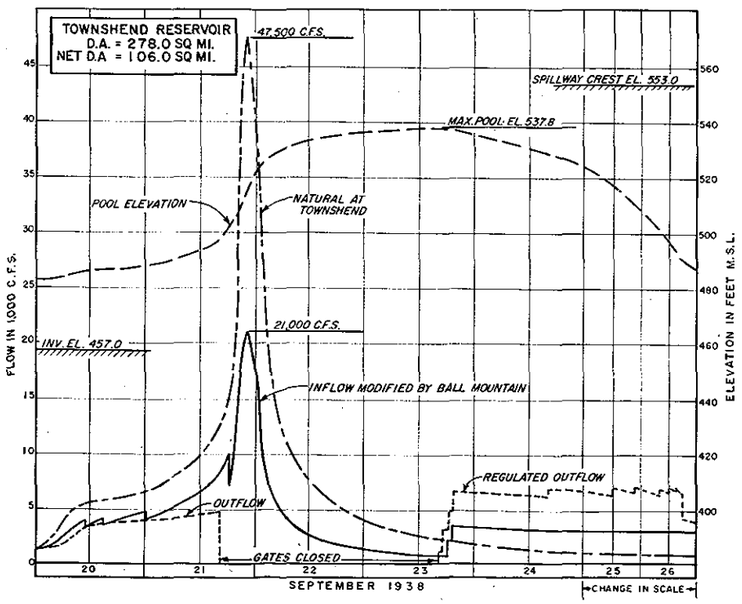
ISOHYETAL MAP
SEPTEMBER 1938 FLOOD

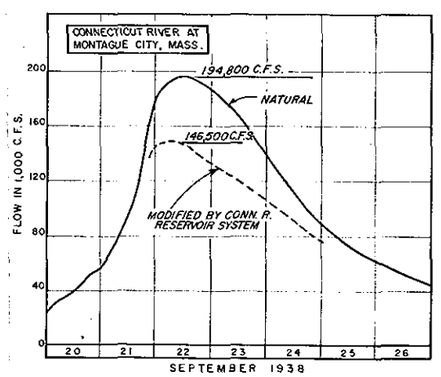
SCALE
8 0 8 MI.











REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY	TR. BY	CA. BY
	G.H.D.	

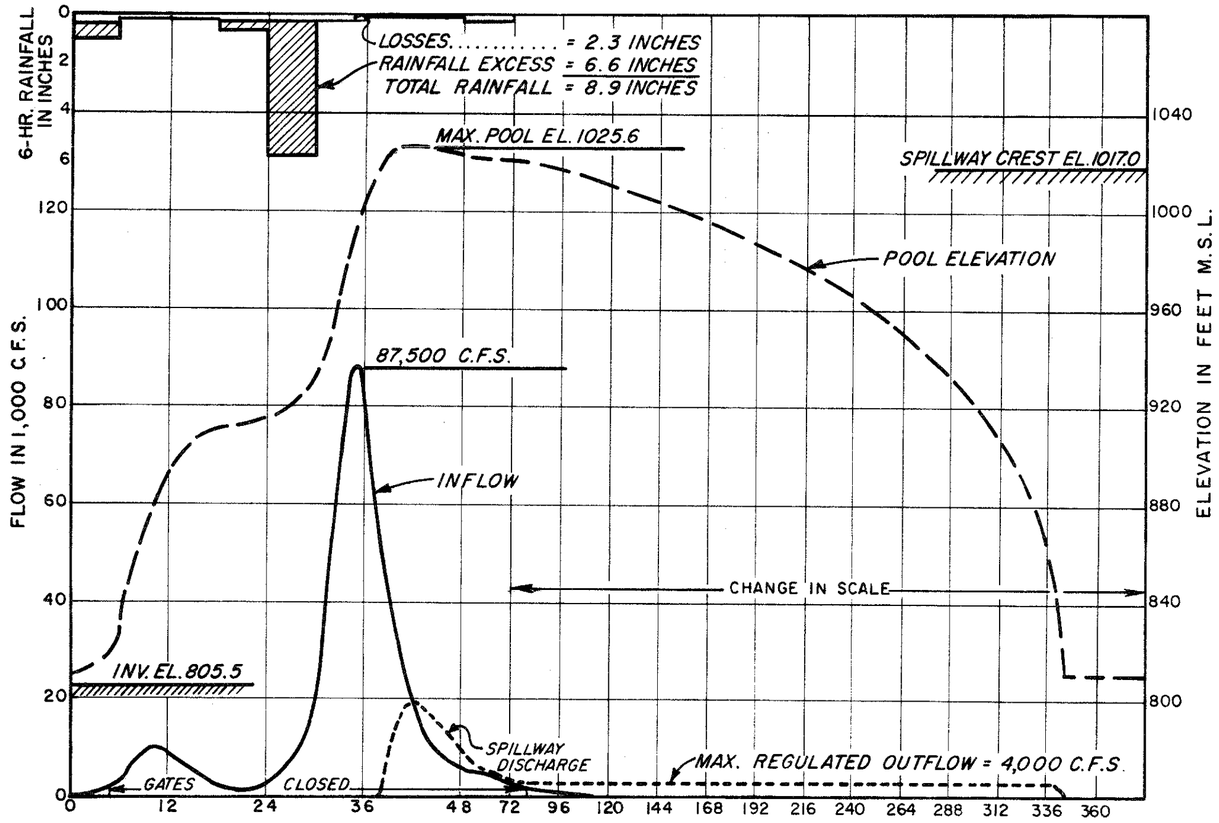
PROJECT ENGINEER
CHIEF, R.B.M. SECTION
SUBMITTED BY
CHIEF, PLANS & SPEC'S. BRANCH
APPROVED:
CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER BASIN
SEPTEMBER 1938 FLOOD
WEST RIVER, VERMONT

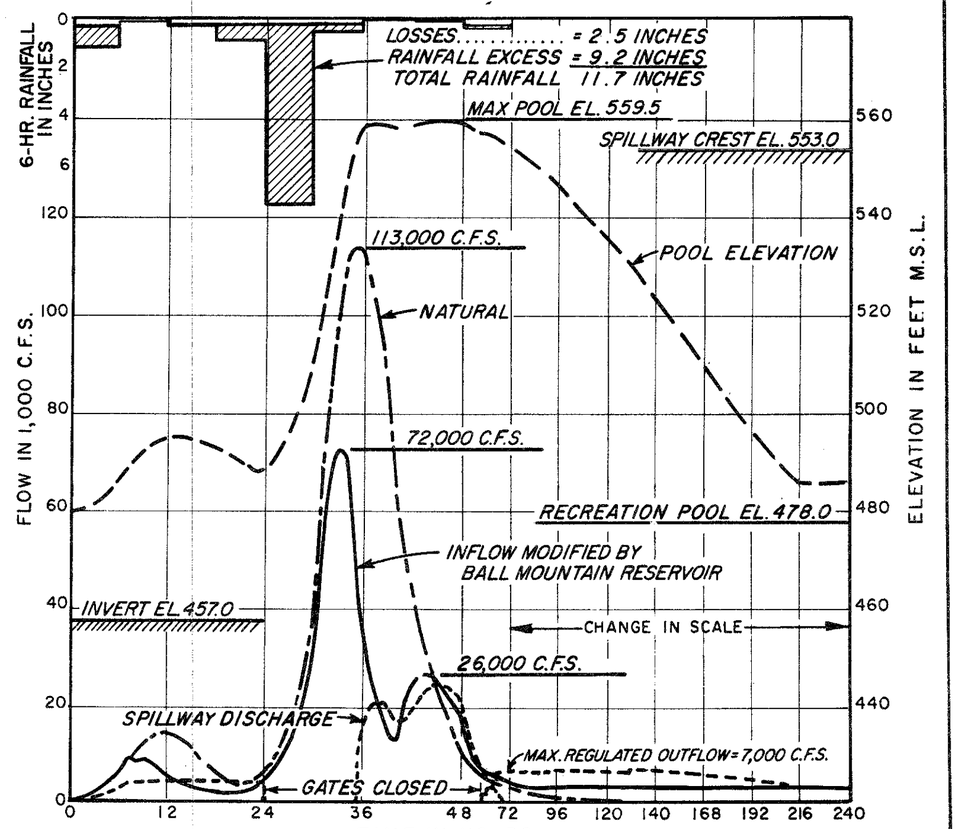
APPROVED
DATE
COL., C.E. DEPUTY DIVISION ENGINEER

SCALE
SPEC. NO. CIV ENG.-19-016-
DRAWING NUMBER
SHEET

PLATE NO. D-5



BALL MOUNTAIN RESERVOIR (D.A. = 172 SQ. MI.)



TOWNSHEND RESERVOIR (D.A. = 278 SQ MI.)
(NET D.A. = 106 SQ MI.)

CONNECTICUT RIVER FLOOD CONTROL

WEST RIVER-VERMONT
STANDARD PROJECT FLOOD

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

PLATE NO. D-6

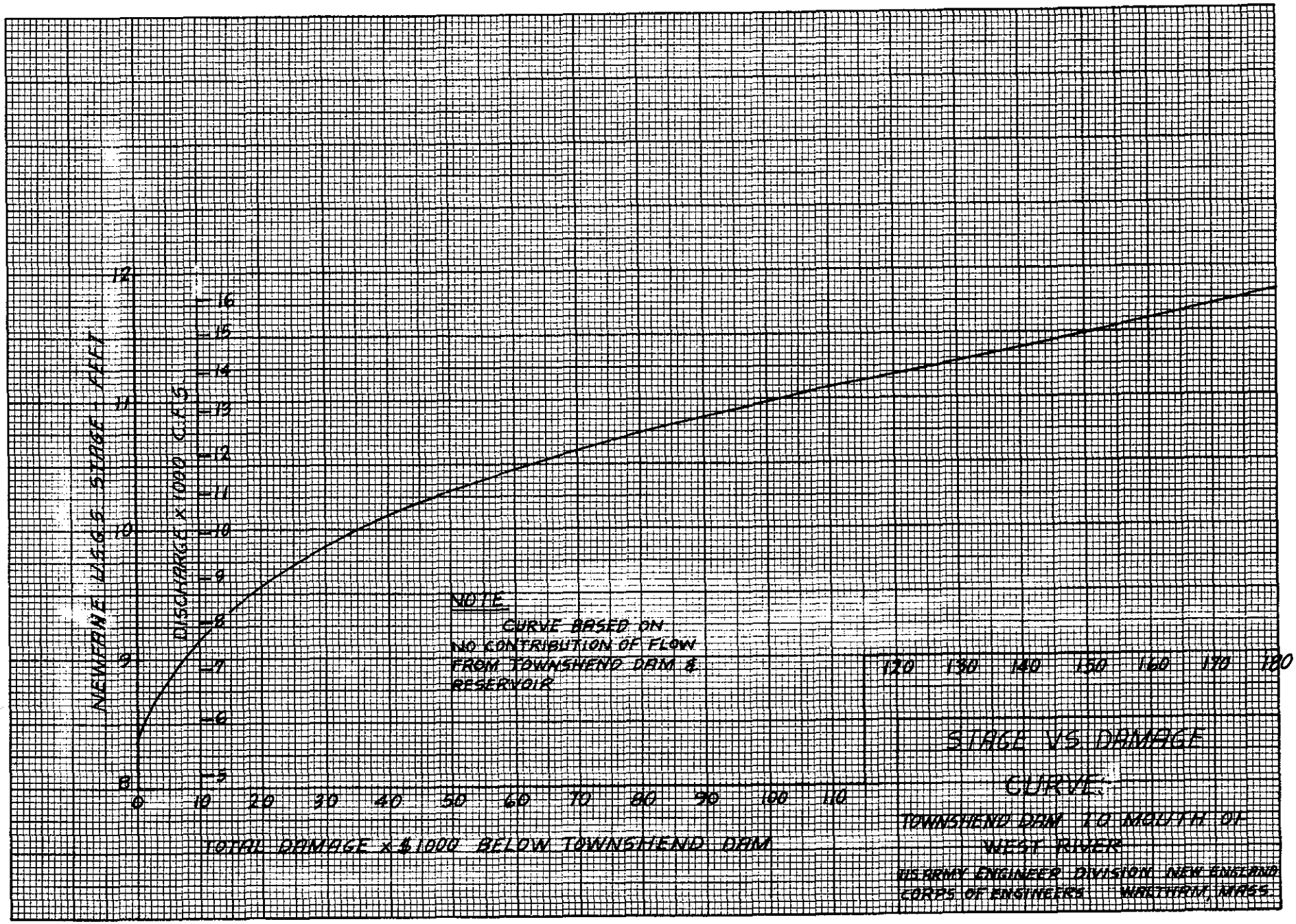

NEWHALL USGS STAGE FEET
DISCHARGE x 1000 C.F.S.
12
11
10
9
8
7
6
5
16
15
14
13
12
11
10
9
8
7
6
5
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
TOTAL DAMAGE x $1000 BELOW TOWNSHEND DAM
NOTE
CURVE BASED ON
NO CONTRIBUTION OF FLOW
FROM TOWNSHEND DAM &
RESERVOIR
STAGE VS DAMAGE
CURVE:
TOWNSHEND DAM TO MOUTH OF
WEST RIVER
US ARMY ENGINEER DIVISION NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.

PLATE NO. D-7

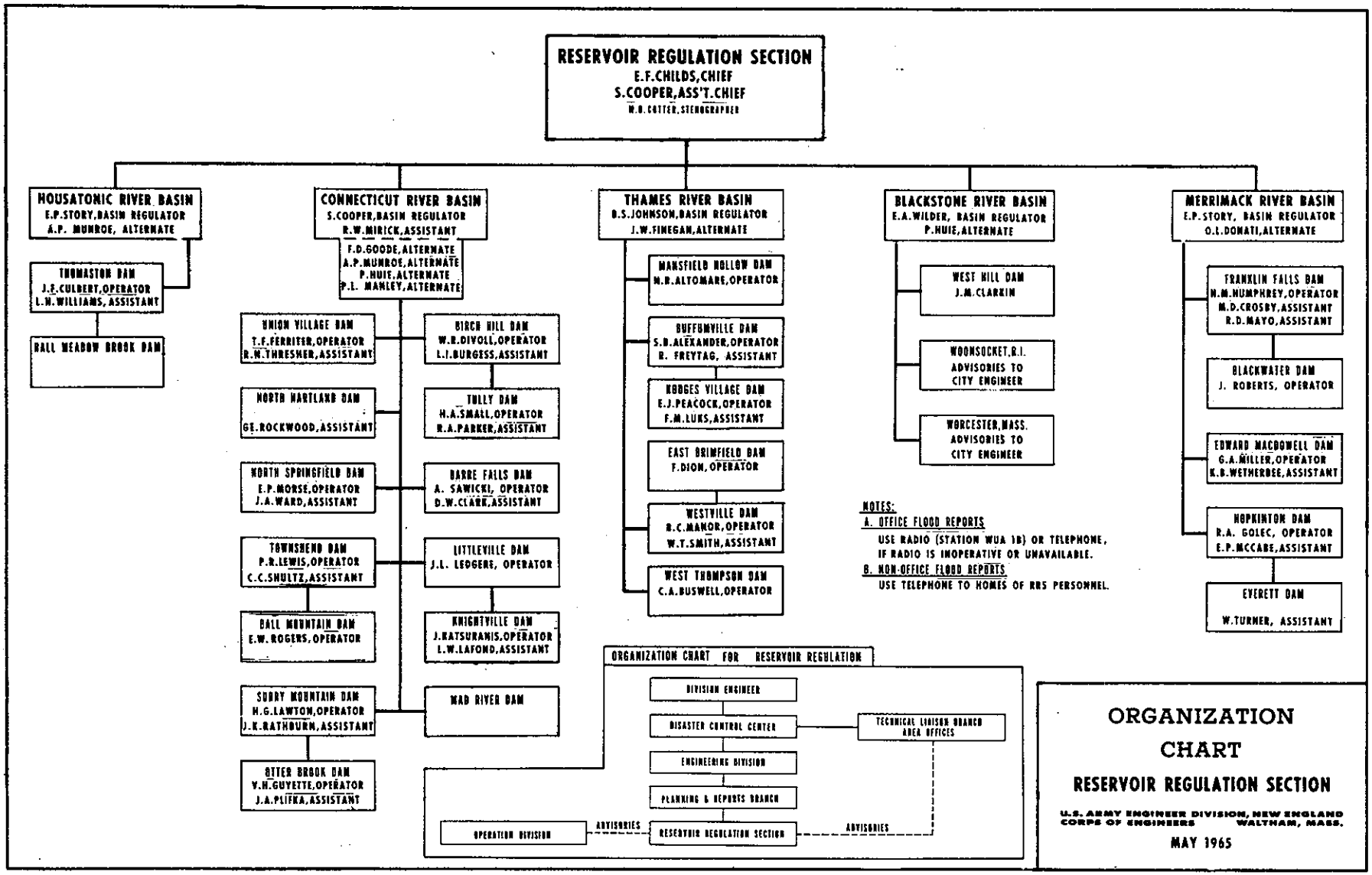

RESERVOIR REGULATION SECTION
E.F.CHILDS,CHIEF
S.COOPER,ASS'T.CHIEF
M.B.COTTER,STENOGRAPHER
HOUSATONIC RIVER BASIN
E.P.STORY,BASIN REGULATOR
A.P. MUNROE, ALTERNATE
THOMASTON DAM
J.F.CULBERT,OPERATOR
L.W.WILLIAMS,ASSISTANT
HALL MEADOW BROOK DAM
CONNECTICUT RIVER BASIN
S.COOPER,BASIN REGULATOR
R.W.MIRICK,ASSISTANT
F.D.GOODE,ALTERNATE
A.P.MUNROE,ALTERNATE
P.HUIE,ALTERNATE
P.L. MANLEY,ALTERNATE
UNION VILLAGE DAM
T.F.FERRITER,OPERATOR
R.W.THRESHER,ASSISTANT
BIRCH HILL DAM
W.R.DIVOLL,OPERATOR
L.I.BURGESS,ASSISTANT
NORTH HARTLAND DAM
G.E.ROCKWOOD,ASSISTANT
TULLY DAM
H.A.SMALL,OPERATOR
R.A.PARKER,ASSISTANT
NORTH SPRINGFIELD DAM
E.P.MORSE,OPERATOR
J.A.WARD,ASSISTANT
BARRE FALLS DAM
A. SAWICKI, OPERATOR
D.W.CLARK,ASSISTANT
TOWNSHEND DAM
P.R.LEWIS,OPERATOR
C.C.SHULTZ,ASSISTANT
LITTLEVILLE DAM
J.L. LEDGERS, OPERATOR
BALL MOUNTAIN DAM
E.W. ROGERS, OPERATOR
KNIGHTVILLE DAM
J.KATSURANIS,OPERATOR
L.W.LAFOND,ASSISTANT
SUNRY MOUNTAIN DAM
H.G.LAWTON,OPERATOR
J.K.RATHBURN,ASSISTANT
MAD RIVER DAM
OTTER BROOK DAM
V.H.GUYETTE,OPERATOR
J.A.PLIFKA,ASSISTANT
THAMES RIVER BASIN
B.S.JOHNSON,BASIN REGULATOR
J.W.FINEGAN,ALTERNATE
MANSFIELD HOLLOW DAM
N.B.ALTOMARE,OPERATOR
BUFFUMVILLE DAM
S.B.ALEXANDER,OPERATOR
R. FREYTAG, ASSISTANT
HODGES VILLAGE DAM
E.J.PEACOCK,OPERATOR
F.M.LUKS,ASSISTANT
EAST BRIMFIELD DAM
F.DION, OPERATOR
WESTVILLE DAM
R.C.MANOR,OPERATOR
W.T.SMITH,ASSISTANT
WEST THOMPSON DAM
C.A.BUSWELL,OPERATOR
BLACKSTONE RIVER BASIN
E.A.WILDER, BASIN REGULATOR
P.HUIE,ALTERNATE
WEST HILL DAM
J.M.CLARKIN
WOONSOCKET,R.I.
ADVISORIES TO
CITY ENGINEER
WORCESTER,MASS.
ADVISORIES TO
CITY ENGINEER
MERRIMACK RIVER BASIN
E.P.STORY, BASIN REGULATOR
O.I.DONATI,ALTERNATE
FRANKLIN FALLS DAM
H.M.HUMPHREY,OPERATOR
M.D.CROSBY,ASSISTANT
R.D.MAYO,ASSISTANT
BLACKWATER DAM
J. ROBERTS, OPERATOR
EDWARD MACDOWELL DAM
G.A.MILLER,OPERATOR
K.B.WETHERBEE,ASSISTANT
HOPKINTON DAM
R.A. GOLEC, OPERATOR
E.P.MCCABE,ASSISTANT
EVERETT DAM
W.TURNER, ASSISTANT
NOTES:
A. OFFICE FLOOD REPORTS
USE RADIO (STATION WUA 18) OR TELEPHONE,
IF RADIO IS INOPERATIVE OR UNAVAILABLE.
B. NON-OFFICE FLOOD REPORTS
USE TELEPHONE TO HOMES OF RRS PERSONNEL.
ORGANIZATION CHART FOR RESERVOIR REGULATION
DIVISION ENGINEER
DISASTER CONTROL CENTER
TECHNICAL LIAISON BRANCH
AREA OFFICES
ENGINEERING DIVISION
PLANNING & REPORTS BRANCH
OPERATION DIVISION
ADVISORIES
RESERVOIR REGULATION SECTION
ADVISORIES
ORGANIZATION
CHART
RESERVOIR REGULATION SECTION
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.
MAY 1965

PLATE NO. D-8

LOG OF RADIO REPORTS - FLOOD CONTROL DAMS

28 May 1965

Line	ITEM	TOWNSHEND DAM		BALL MTN. DAM									Line
1	Time of Observation	0800		0800									1
2	Precipitation (last 24 hours)	0.17		0									2
3	Form of Precipitation	Rain		—									3
4	Present Weather	Cloudy		Clear									4
5	Pool Stage	22.21		4.33									5
6	Tendency	Steady		F									6
7	Gate Openings	0-12-0		0-3-0									7
8	Tailwater Gage	4.15											8
9	Outflow	130											9
10	INDEX POINTS												10
11													11
12													12
13													13
14													14
15													15
	REMARKS												

REPORT

SAMPLE

NED FORM APR 61 477

SHEET -1-

NED FORM 503
MAR63

REGULATION OF *TOWNSHEND* AND *BALL MOUNTAIN* RESERVOIRS

LOG OF REPORTS AND INSTRUCTIONS

DATE AND TIME OF REPORT	TOWNSHEND RES.											BALL MOUNTAIN RES.							PRECIPITATION				WEST RIVER AT NEWFANE			RIVER AT			RIVER AT			
	RES POOL		GATE OPENING								OUTFLOW		RES POOL		GATE OPENING			OUTFLOW															
	HOUR	STAGE	1	2	3	■	■	■	■	■	T.W.	C.F.S.	HOUR	STAGE	1	2	3	T.W.	C.F.S.	LOCATION	HOUR	INCHES INC.	INCHES ACC.	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S	HOUR	STAGE	C.F.S
7/3/63	1300	22.04	0	F	0							200	1300	4.0	3	3	3		150	Townshend	1300	—	1.20	1400	4.16	110						
																				Ball Mtn.	1300	—	1.00									
(Instr. Call back @ 1.5")																																
1615	1600	22.26	0	F	0							220	1600	4.3	3	3	3		190	Townshend	1600	.35	1.55	1600	4.22	137						
																				Ball Mtn.	1600	.40	1.40									
(Instr. Call back @ 2.0")																																
7/4/63	0800	24.30	0	F	0							900	0800	4.5	3	3	3		250	Townshend	0800	.50	2.05	0800	5.45	925						
																				Ball Mtn.	0800	.25	1.65									
(Instr. Close gates to 0-3-0 at Townshend; 1-1-1 at Ball Mtn. — Call back @ 2.5 inches or 1200 Hrs.)																																
	0830	24.30	0	3	0							220	0880	4.5	1	1	1		200													
1220	1200	28.5	0	3	0							650	1200	5.0	1	1	1		230	Townshend	1200	.10	2.15	1000	6.00	1490						
																				Ball Mtn.	1200	.15	1.80	1200	5.85	1325						
Storm has ended, West River Stages Falling																																
(Instr. Retain gate setting at Townshend until pool returns to 24' — Reset Ball Mtn. gates to 3-3-3 — Call back when Townshend pool 24')																																
1515	1500	24.0	0	3	0							200	1500	4.0	3	3	3		200	Townshend	1500	0	2.15	1500	5.5	970						
																				Ball Mtn.	1500	0	1.80									
(Instr. set gates to normal 0-F-0 setting)																																
	1530	24.0	0	F	0							900	1500	4.0	3	3	3		200													
End of Operation																																

SAMPLE REGULATION

GATE OPERATION RECORD

TOWNSHED RESERVOIRS JULY MONTH 1963 YEAR
BALL MTN.

DATE	HOUR	RES. STAGE Feet	GATE OPENING IN FEET*								OUTFLOW c.f.s.	REMARKS
			#1	#2	#3	#4	#5	#6	#7	#8		
TOWNSHEND												
7/4/63	0800	24.30	0	F	0						900	
	0830	24.30	0	3	0						220	Start Operation
	1500	24.00	0	3	0						200	
	1530	24.00	0	F	0						900	End Operation
BALL MTN.												
7/4/63	0800	4.5	3	3	3						250	
	0830	4.5	1	1	1						200	Start Operation
	1500	4.0	1	1	1						220	
	1530	4.0	3	3	3						200	End Operation

SAMPLE GATE RECORD

*Indicate full opened gate by "F"

SIGNED B. S. Doe
OPERATOR

DATE 7/4/63

D FORM FEB 60 90 Replaces Ned Form 90 of Jan 53 and Ned Forms 91 and 101 which are obsolete

SHEET -3

A T T A C H M E N T I

LOCAL PROTECTION PROJECT

WESTON, VERMONT

ATTACHMENT I

TABLE OF CONTENTS

LIST OF PLATES

Plate No.	Title
I-1	Plan and Profile
I-2	Dike and Stoplog Structure

PERTINENT DATA
WESTON, VERMONT
LOCAL PROTECTION PROJECT

CHANNEL IMPROVEMENT	
Length	1,700 feet
Bottom Width	Variable to 40 feet
Side Slopes	1 on 1 and 1 on 2
DIKES	
Length	75 feet ±
Top Width	10 feet
Maximum Height	4 feet
Side Slopes	1 on 2
STOPLOG STRUCTURE	
Size	4" x 4" timber logs
Length	8 feet
PLACED IN OPERATION	July 1957
MAINTAINED BY	Town of Weston

ATTACHMENT I
WESTON, VERMONT
LOCAL PROTECTION PROJECT

1. AUTHORIZATION

Construction of a local protection project on the West River at Weston, Vermont, in the Connecticut River basin, was approved by the Chief of Engineers on 7 June 1956 pursuant to the authority contained in Section 208 of the Flood Control Act, approved 3 September 1954.

2. LOCATION

Weston is situated in the south central portion of Vermont about 21 miles northwest of Bellows Falls (see Plate No. D-2 of main report). The village borders the banks of the West River 45 miles upstream from its confluence with the Connecticut River at Brattleboro. The project construction extends about 1,700 feet downstream from the Vermont Guild Mill and dam in the upper part of the village.

3. DESCRIPTION OF PROJECT

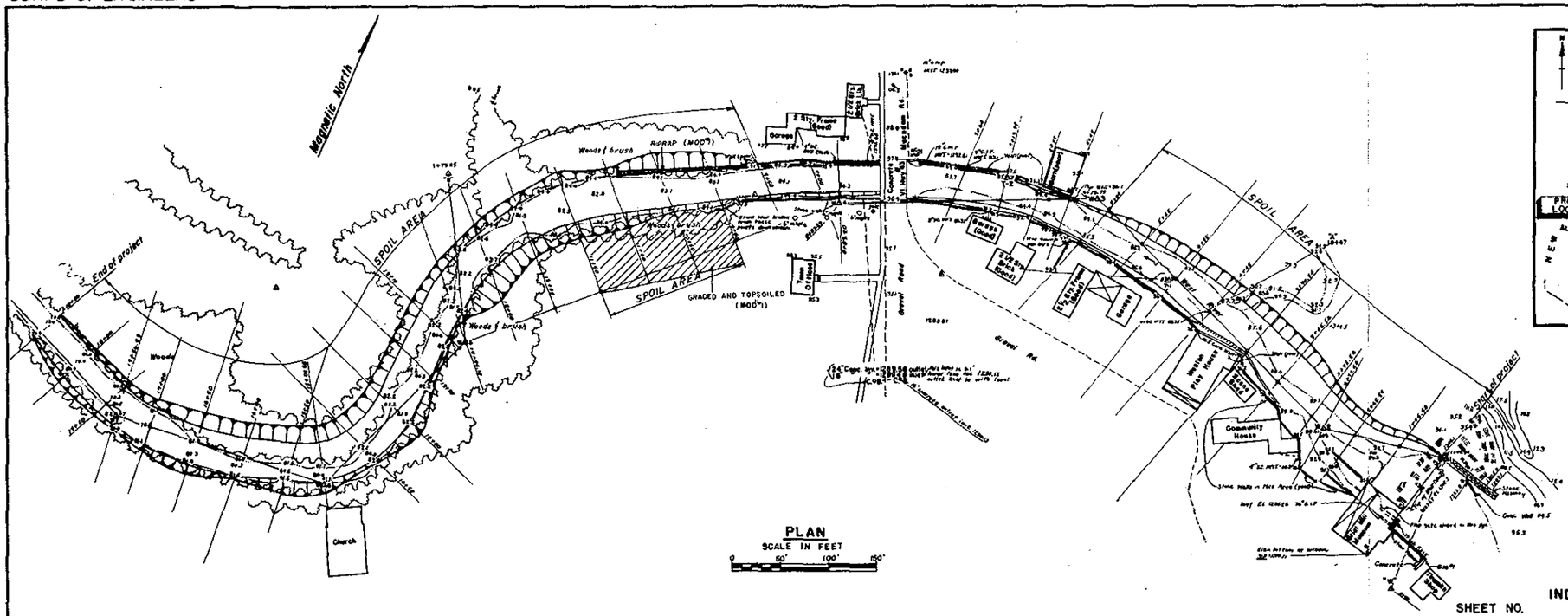
The project, completed in 1957, consists of deepening and widening the channel; clearing, snagging and removal of boulders from the streambed; riprapping slopes on the riverside of the walled section and along a section of the west bank of the river; construction of a small dike and stoplog structure extending southerly from the upstream side of the Vermont Guild Mill building to high ground; and repair of a section of the masonry wall on the left bank upstream of the Landgrove Street bridge. A plan and profile of the protective works is shown on Plate No. I-1. Plate No. I-2 contains details of the dike and stoplog structure.

4. PROTECTION PROVIDED

The protected area is between Route 8 and the West River and extends approximately 1,400 feet along and adjacent to the riverbank. The construction provides protection to the area from moderate floodflows similar to the flood of June 1952.

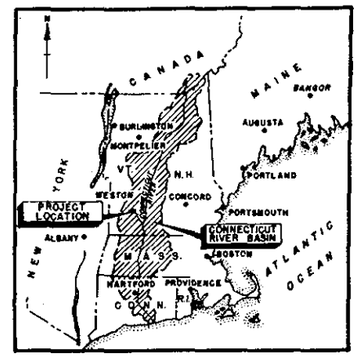
CORPS OF ENGINEERS

U.S. ARMY



PLAN
SCALE IN FEET
0 50' 100' 150'

NOTE:
Sections shown are not normal to ℄ of channel.

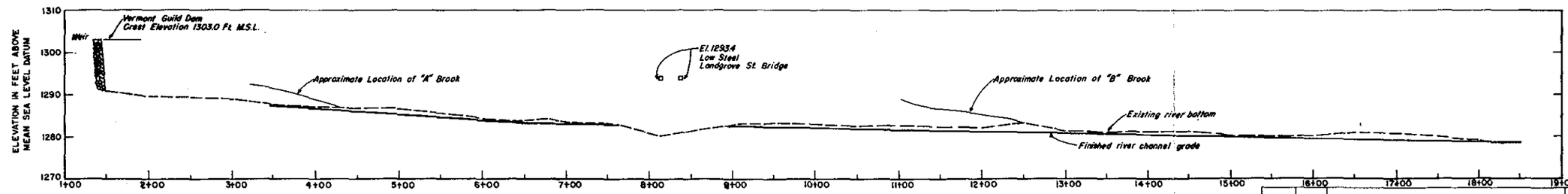


VICINITY MAP
SCALE IN MILES
40 0 40 80

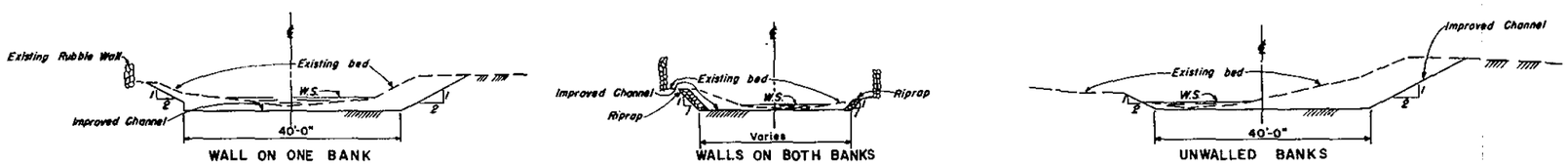
INDEX OF DRAWINGS

SHEET NO.	TITLE	DWG. NO.
1	GENERAL PLAN AND PROFILE	CT-1-4091
2	CONSTRUCTION LAYOUT	CT-1-4092
3	CROSS SECTIONS SHEET 1	CT-1-4093
4	" " " 2	CT-1-4094
5	" " " 3	CT-1-4095
6	" " " 4	CT-1-4096
7	BROOK SECTION AND PROFILE	CT-1-4097
8	CONSTRUCTION SIGN	CT-1-4098

NOTE:
1. Spoil Areas To Extend 100 Feet From ℄ Of Existing Stream In Areas Designated.
2. Easement To Extend 30 Feet From ℄ Of Existing Stream In Walled Section And 50 Feet In Unwalled Section.



PROFILE
SCALES: HOR. 1"=50'
VERT. 1"=10'



TYPICAL CHANNEL SECTIONS
SCALE: HOR. 1"=10'
VERT. 1"=10'

W.S. = Water Surface as of July-August 1956.

REVISION	DATE	DESCRIPTION	BY
Mod^n 1	1/7/57	Riprap Added, Topsoil & Grade Spoil Area	

CORPS OF ENGINEERS U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
J.E.M.	E.V.K.	R.Y.

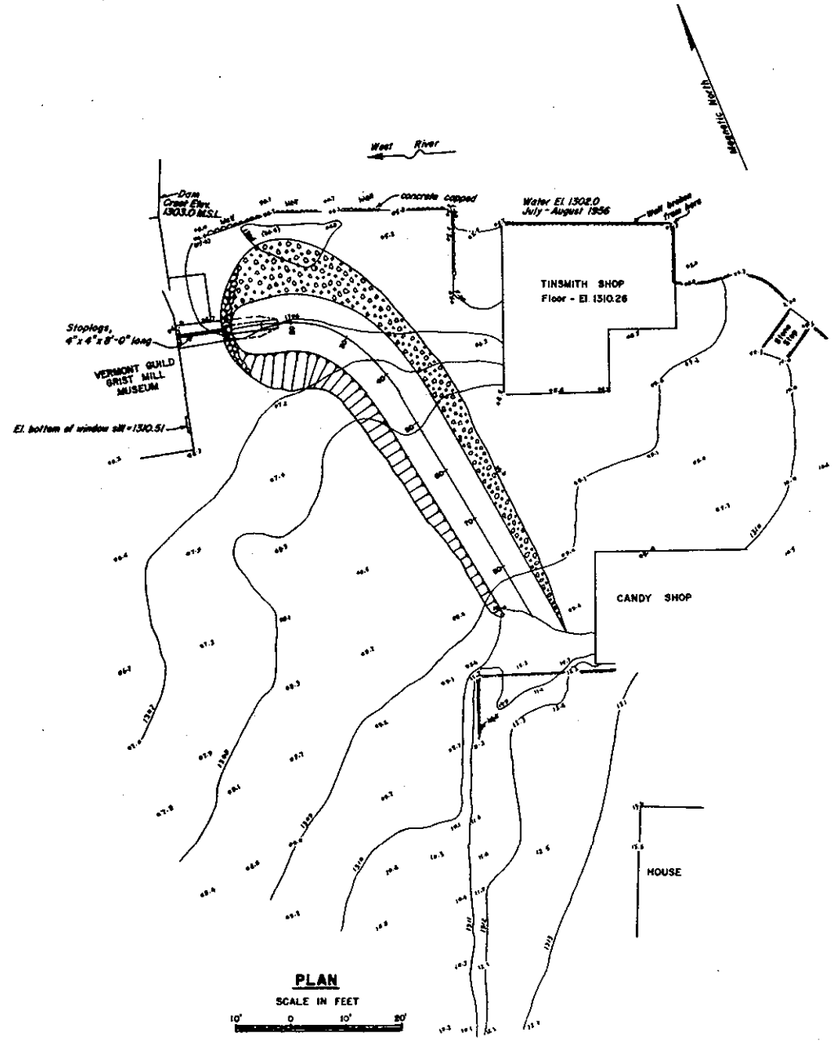
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER CHANNEL IMPROVEMENT
GENERAL PLAN AND PROFILE
WESTON, VERMONT
WEST RIVER, VERMONT

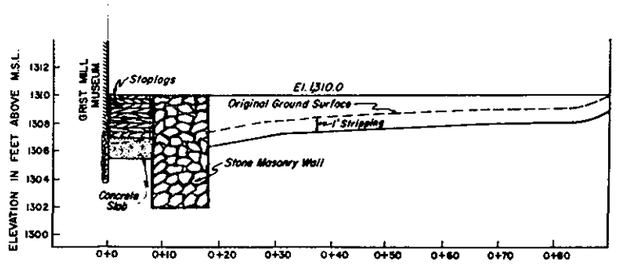
PROJECT ENGINEER
SUBMITTED by
CHIEF, PLANS & SUPPS BRANCH
APPROVED
CHIEF ENGINEERING DIV.

APPROVED
DATE SEPT. 1956
LT. COL. C.E. ARMY DIVISION ENGINEER

SCALE AS SHOWN | SPEC. NO. | CIV. ENG. -
DRAWING NUMBER
CT-1-4091
SHEET 1 OF 8

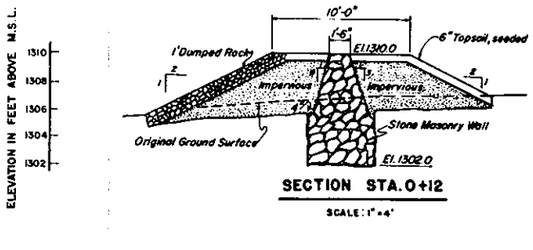
PLATE NO. 1-1





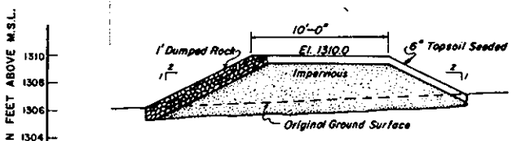
PROFILE ALONG ℄ WALL AND DIKE

SCALE: HOR. 1"=10' VERT. 1"=4'



SECTION STA. 0+12

SCALE: 1"=4'



SECTION STA. 0+20

SCALE: 1"=4'

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DR. BY	TR. BY	CK. BY
	M S	

PROJECT ENGINEER
SUBMITTED BY
CHIEF, PLANNING & REP'TS BRANCH
APPROVED
CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER CHANNEL IMPROVEMENT
DETAIL OF DIKE AND STOP-LOG STRUCTURE
WESTON, VERMONT
WEST RIVER, VERMONT

APPROVED DATE
LT. COL. C. E. ABBOTT, DIVISION ENGINEER

SCALE AS SHOWN

DRAWING NUMBER
CT-1-4138A

SHEET 1 OF 1

PLATE NO. 1-2

A T T A C H M E N T II

BALL MOUNTAIN DAM AND RESERVOIR

WEST RIVER, VERMONT

ATTACHMENT II

TABLE OF CONTENTS

LIST OF PLATES

Plate No.	Title
II-1	General Development Plan
II-2	General Plan
II-3	Embankment Sections
II-4	Spillway and Outlet Works
II-5	Spillway Profile

PERTINENT DATA
BALL MOUNTAIN DAM AND RESERVOIR
WEST RIVER, VERMONT

DRAINAGE AREA (Square Miles)	172
RESERVOIR	
Permanent Pool	No permanent pool
Flood Control Storage	
Capacity (acre-feet)	54,600
Inches Runoff	5.95
Area - Spillway Crest (acres)	800
DAM	
Type	Rolled earth and rockfill
Length (feet)	915
Top Elevation (feet msl)	1,052
Maximum Height (feet)	265
SPILLWAY	
Type	Concrete ogee
Length (feet)	235
Crest Elevation (feet msl)	1,017
OUTLET WORKS	
Type	Circular tunnel
Conduit Size	13'-6" diameter
Length (feet)	864
Capacity - Spillway Crest (cfs)	11,400
Gates	Three 5'8" x 10'0"
SPILLWAY DESIGN FLOOD	
Inflow (cfs)	190,000
Outflow (cfs)	150,000 spillway discharge
	12,800 outlet discharge
Maximum Surcharge (feet)	30.0

PROJECT COST	$11,100,000
PLACED IN OPERATION	September 1961
MAINTAINED BY	NED

ATTACHMENT II
BALL MOUNTAIN DAM AND RESERVOIR
WEST RIVER, VERMONT

1. AUTHORITY

Ball Mountain Dam and Reservoir is a unit of the comprehensive plan for flood control in the Connecticut River basin. Authorization is contained in the Flood Control Act of 1938 (Public Law 761, 75th Congress, 3rd Session) as modified by the Flood Control Act of 1941 (Public Law 228, 77th Congress, 1st Session) and the Flood Control Act of 1944 (Public Law 534, 78th Congress, 2nd Session). Construction of the project was initiated in April 1956 and completed in October 1961.

2. PROJECT LOCATION

The Ball Mountain Dam and Reservoir is located on the West River in the townships of Jamaica and Londonderry, Windham County, Vermont. It is in the southeastern part of the state, about 29 miles upstream of the confluence of the Connecticut and West Rivers at Brattleboro, Vermont and 27 miles north of the Massachusetts state line.

3. DESCRIPTION OF PROJECT

Major project components consist of a rolled earth and rockfill dam, chute spillway and an outlet works. At spillway crest Ball Mountain Reservoir has a capacity of 54,600 acre-feet, which is equivalent to about 6 inches of runoff from the drainage area of 172 square miles. When filled to spillway crest, the reservoir is about 6.5 miles long with a surface area of about 800 acres. A reservoir map of Ball Mountain Dam is shown on Plate No. II-1.

a. Dam. The dam consists of rolled earth and rockfill embankment 915 feet long with a maximum height of 265 feet (Plate Nos. II-2 and II-3). The top of dam at elevation 1052 feet msl provides for 30 feet of surcharge and 5 feet of freeboard. The top width of the dam is 20 feet and the side slopes vary from 1 on 1.75 to 1 on 2.50.

b. Spillway. The chute spillway is located on the right abutment adjacent to the dam. The spillway is an uncontrolled ogee

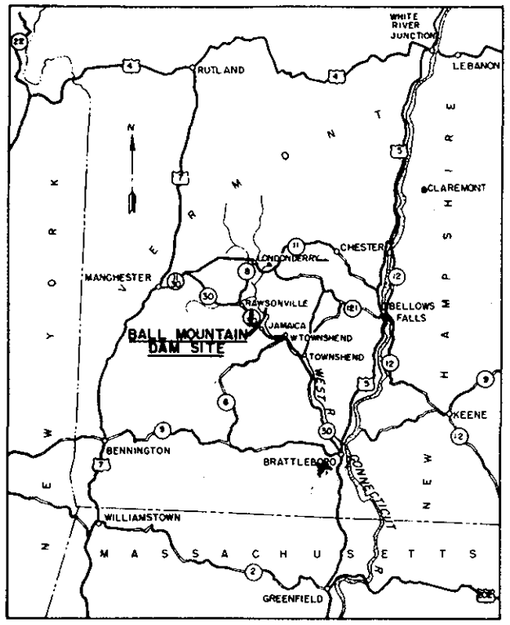
weir with a fixed crest at elevation 1017 feet msl and a length of 235 feet. The spillway approach channel is about 450 feet long with a level invert at elevation 1002 feet msl. The spillway discharge channel varies in bottom width from 228 feet at the toe of the spillway to 100 feet about 375 feet downstream. The invert slopes vary from 0.25 to 0.40 percent. A plan and profile of the spillway is shown on Plate Nos. II-4 and II-5.

c. Outlet works. The outlet works shown on Plate No. II-4 consist mainly of an intake tower, a conduit and an outlet channel. The intake tower houses the equipment necessary to operate the three 5'8" x 10'0" gates that control the flow in the conduit. The conduit, comprised of a concrete circular tunnel 13'6" in diameter, is 864 feet long and slopes at 0.002. At the end of the circular tunnel, the outlet works flare to the outlet channel which has a constant bottom width of 32 feet and slopes at 0.02 until it empties into the West River.

d. Recreation. Recreational activities at the damsite consist mainly of hiking and picnicking. The Winhall and West River recreational areas shown on Plate No. II-1 are the designated picnic zones.

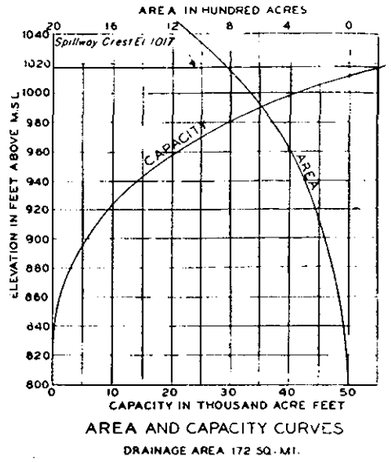
CORPS OF ENGINEERS

U S ARMY



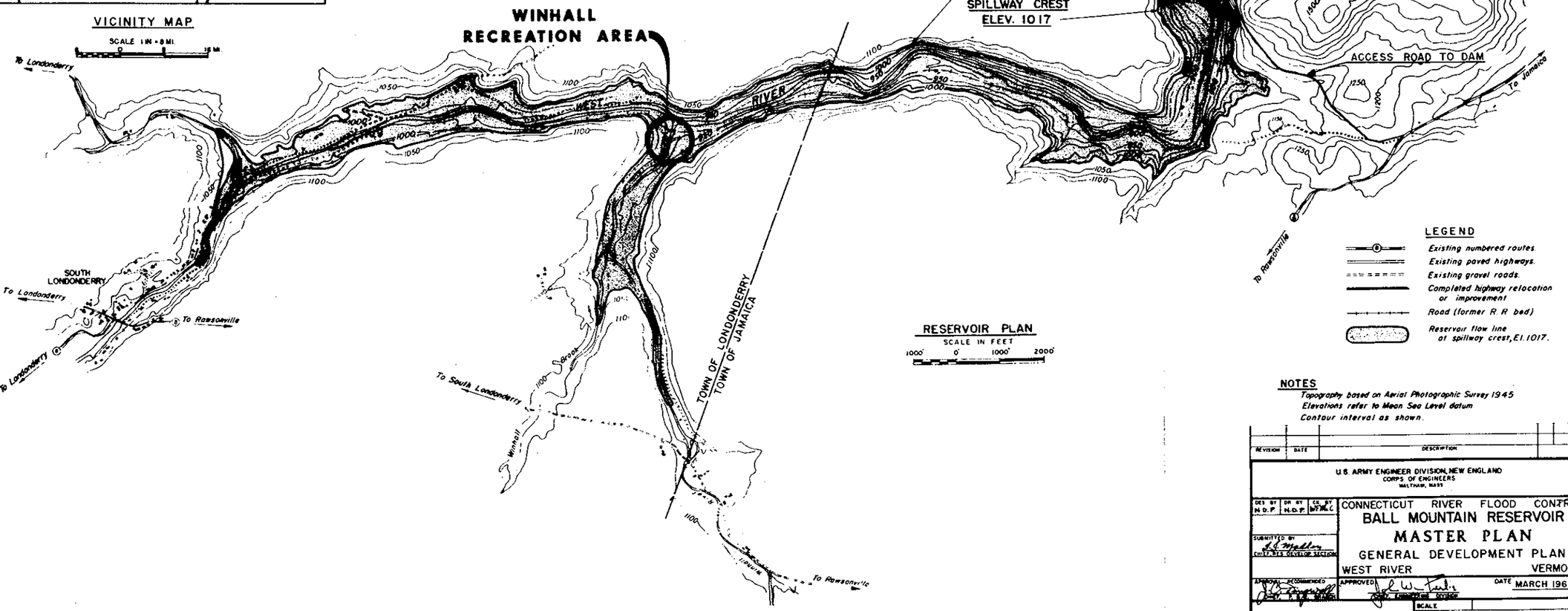
VICINITY MAP

SCALE 1 IN = 8 MI.



AREA AND CAPACITY CURVES

DRAINAGE AREA 172 SQ. MI.



RESERVOIR PLAN

SCALE IN FEET

1000' 0' 1000' 2000'

NOTES

Topography based on Aerial Photographic Survey 1945

Elevations refer to Mean Sea Level datum

Contour interval as shown.

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES BY	DR BY	CK BY
N.D.P	N.D.P	W.F.M.C.

CONNECTICUT RIVER FLOOD CONTROL

BALL MOUNTAIN RESERVOIR

MASTER PLAN

GENERAL DEVELOPMENT PLAN

WEST RIVER VERMONT

SUBMITTED BY: Chief, R.E.S. Development Section

APPROVAL RECOMMENDED

APPROVED: Chief, Engineering Division

DATE MARCH 1961

SCALE

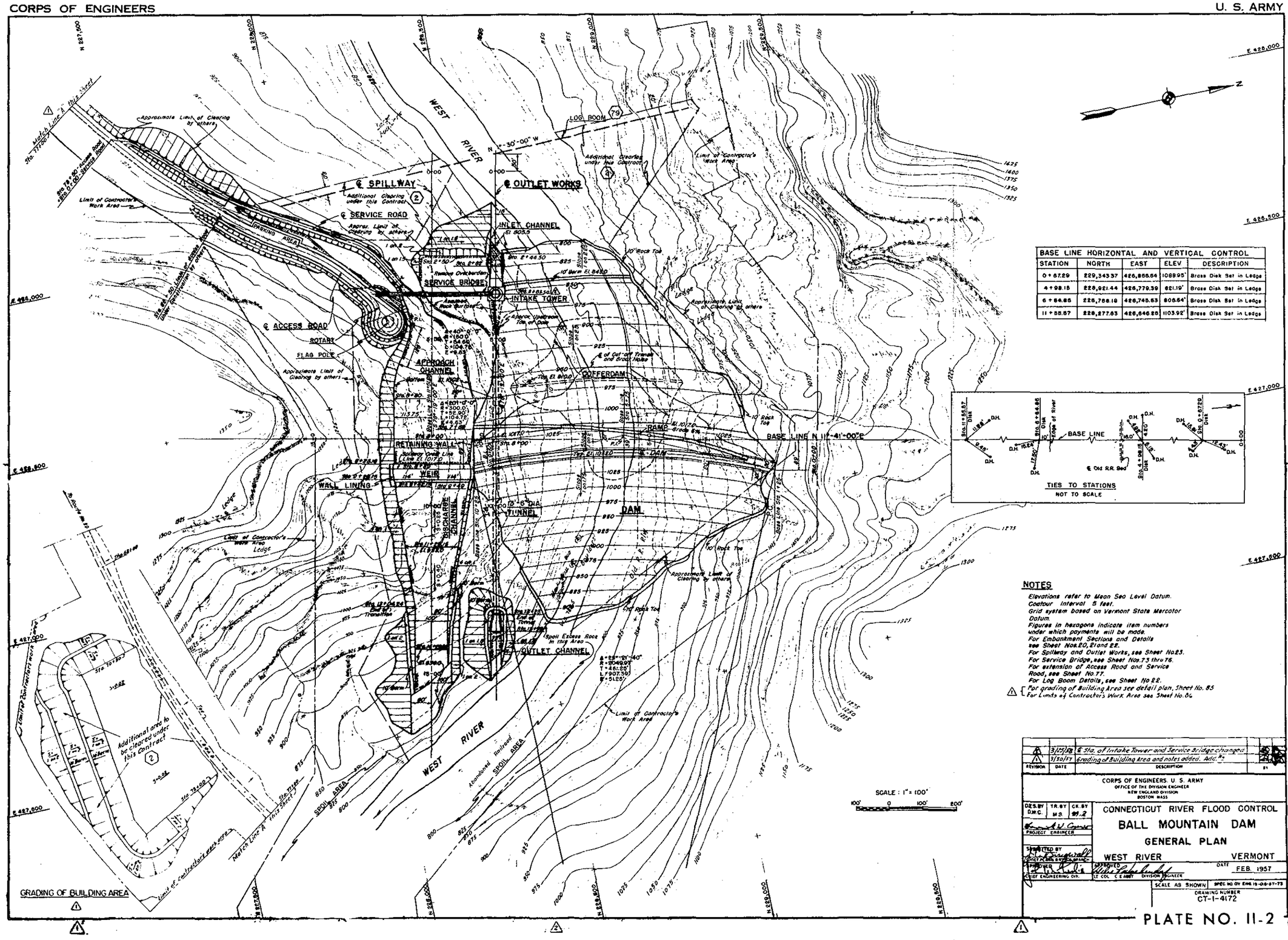
DRAWING NUMBER CT-1-5658

SHEET 3 OF 12

PLATE NO. II-1

CORPS OF ENGINEERS

U. S. ARMY



BASE LINE HORIZONTAL AND VERTICAL CONTROL				
STATION	NORTH	EAST	ELEV	DESCRIPTION
0+67.29	229,343.37	426,858.64	1088.95'	Bronze Disk Set in Ledge
4+98.15	228,921.44	426,779.39	821.19'	Bronze Disk Set in Ledge
6+84.85	228,788.18	426,745.63	808.64'	Bronze Disk Set in Ledge
11+88.67	228,277.65	426,646.26	1103.92'	Bronze Disk Set in Ledge

NOTES

Elevations refer to Mean Sea Level Datum.
Contour Interval 5 feet.
Grid system based on Vermont State Mercator Datum.
Figures in hexagons indicate item numbers under which payments will be made.
For Embankment Sections and Details see Sheet Nos.20, 21 and 22.
For Spillway and Outlet Works, see Sheet No.23.
For Service Bridge, see Sheet Nos.73 thru 76.
For extension of Access Road and Service Road, see Sheet No 77.
For Log Boom Details, see Sheet No 22.
⚠1 For grading of Building Area see detail plan, Sheet No. 85
For Limits of Contractors Work Area see Sheet No. 84

REVISION	DATE	DESCRIPTION	BY
⚠3	3/25/58	℄ Sta. of Intake Tower and Service Bridge changed	
⚠2	9/30/57	Grading of Building Area and notes added. Add. #2	

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON MASS

DES. BY D.W.C.	TR. BY MS	CK. BY W.J.Z

PROJECT ENGINEER

SUBMITTED BY
CHIEF, CONSTRUCTION DIV.

APPROVED
CHIEF ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN DAM
GENERAL PLAN
WEST RIVER VERMONT

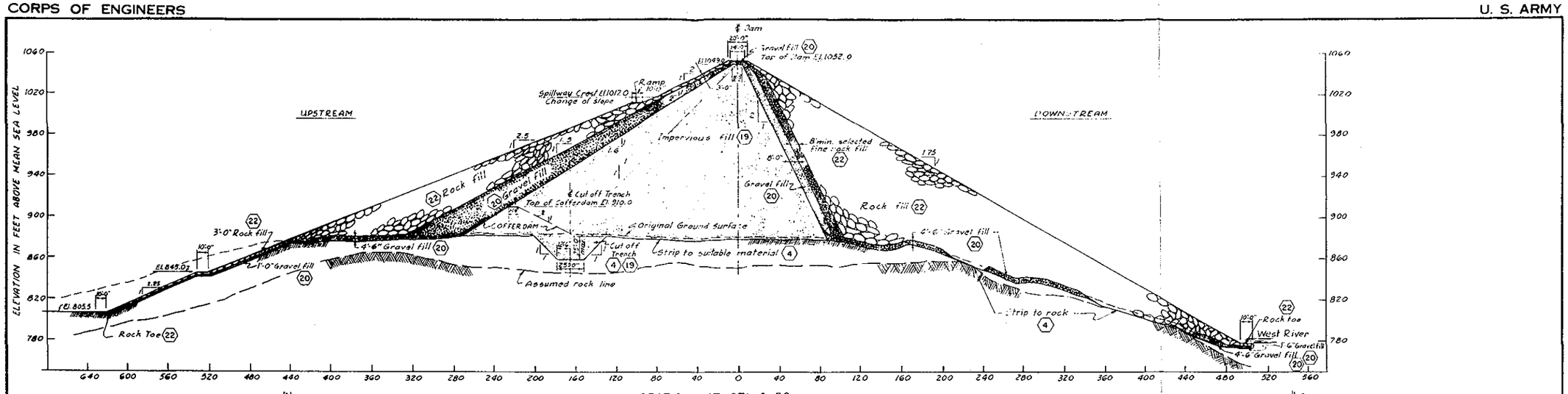
APPROVED
LT. COL. C.E. ARMY DIVISION ENGINEER
DATE FEB. 1957

SCALE AS SHOWN
SPEC NO CIV ENG 19-020-57-73
DRAWING NUMBER
CT-1-4172

PLATE NO. II-2

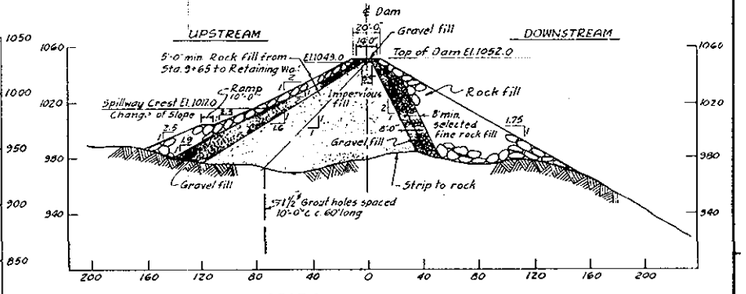
CORPS OF ENGINEERS

U. S. ARMY



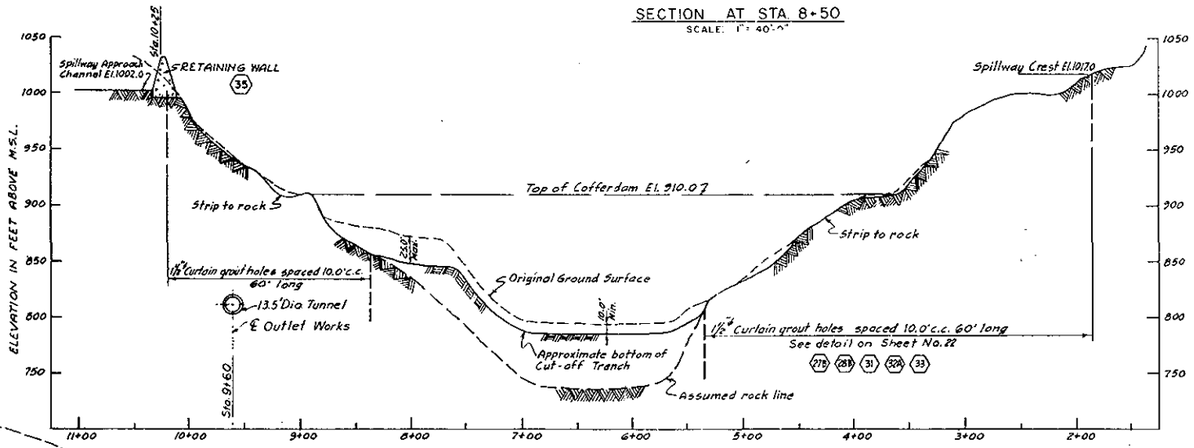
SECTION AT STA 8+50

SCALE: 1" = 40'-0"



SECTION AT STA. 9+75

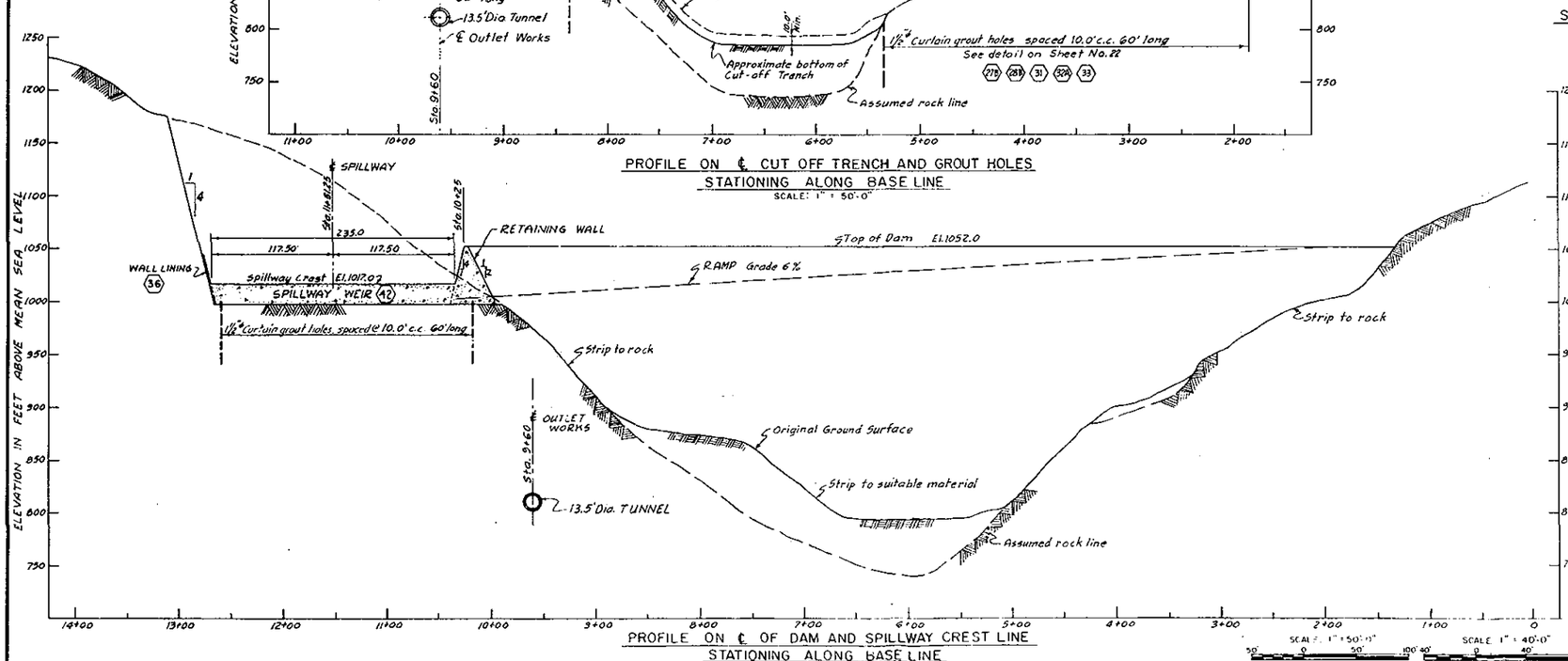
SCALE: 1" = 40'-0"



PROFILE ON ℄ CUT OFF TRENCH AND GROUT HOLES

STATIONING ALONG BASE LINE

SCALE: 1" = 50'-0"



PROFILE ON ℄ OF DAM AND SPILLWAY CREST LINE

STATIONING ALONG BASE LINE

SCALE 1" = 50'-0"

SCALE 1" = 50'-0"

SCALE 1" = 40'-0"

NOTES:

Elevations refer to Mean Sea Level Datum

For general notes applying to this sheet, see Sheet No. 19

Sections are normal to center line of dam at projected Base Line Stations.

Figures in hexagons indicate Item Numbers under which payment will be made.

For top of dam detail, see Sheet No. 22

For rock toe details, see Sheet No. 20

REVISION	DATE	DESCRIPTION	BY

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DES BY DWG.	DR BY B.U	CK BY

CONNECTICUT RIVER FLOOD CONTROL

BALL MOUNTAIN DAM

EMBANKMENT SECTIONS AND PROFILES

PROJECT ENGINEER

SUBMITTED BY

CHIEF, PLANS & SPECS. BR.

APPROVED

CHIEF ENGINEERING DIV.

WEST RIVER VERMONT

APPROVED DATE FEB 1957

LT. COL. C.E. ASST. DIVISION ENGINEER

SCALE AS SHOWN SPEC NO DIV ENG 19-016-57-73

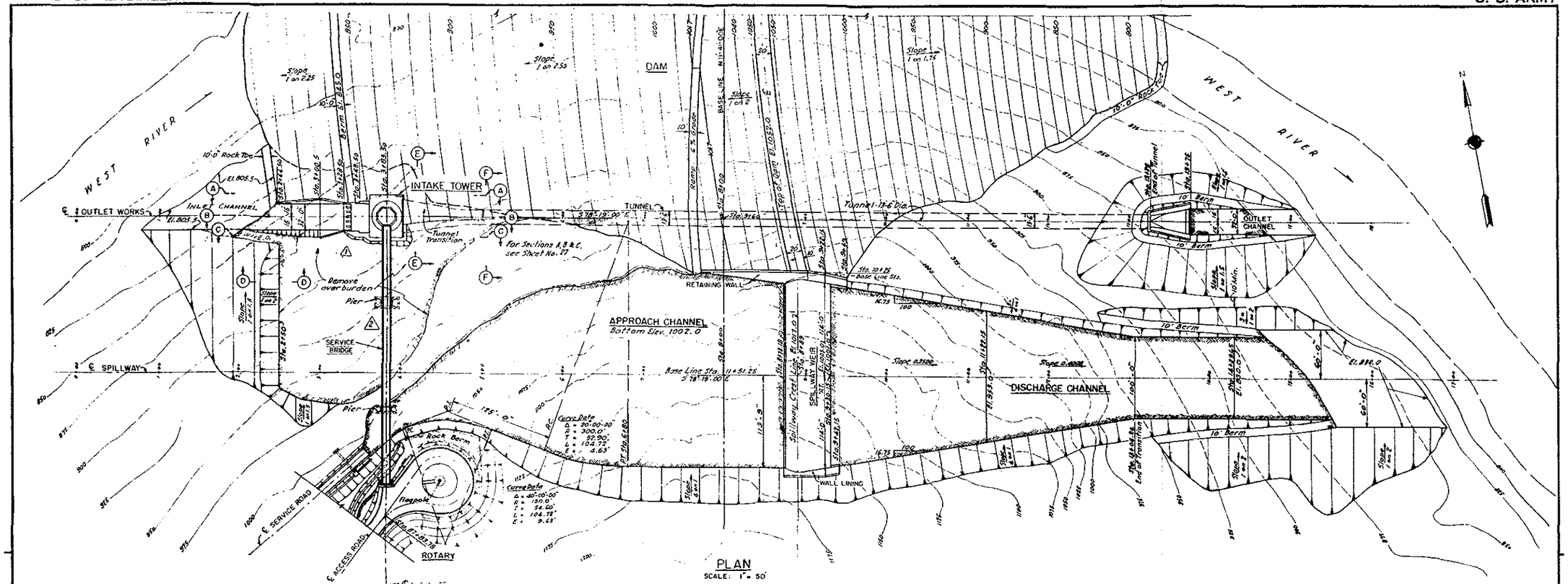
DRAWING NUMBER

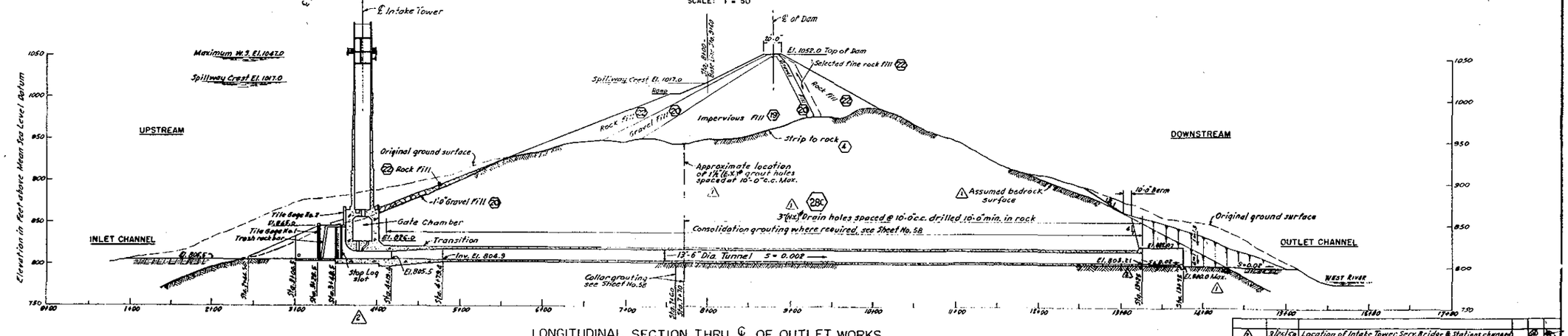
CT-I-4174

PLATE NO. II-3 (21)

CORPS OF ENGINEERS

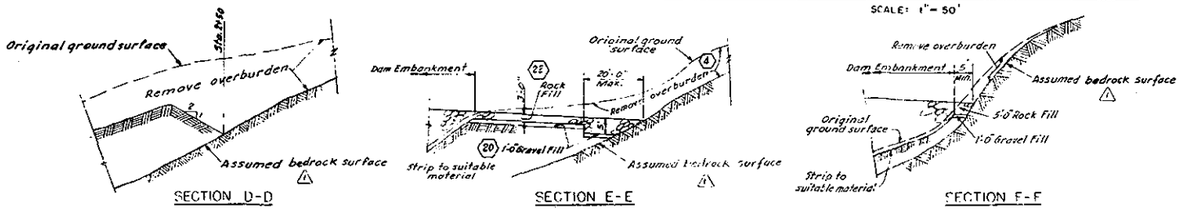
U. S. ARMY





LONGITUDINAL SECTION THRU ℄ OF OUTLET WORKS

SCALE: 1" = 50'



TYPICAL SECTIONS

SCALE 1" = 20'

NOTES

Elevations refer to Mean Sea Level Datum.
For Spillway Channel Sections, see Sheet No. 26
For Walls and Weir concrete details, see Sheet Nos. 25 & 26.
For Outlet Works Sections, see Sheet No. 27.
For Intake Tower concrete details, see Sheet Nos. 31 thru 36.
For Tunnel Transition and Tunnel details, see Sheet Nos. 57 & 58
For Plan of Access Road and Service Road, see Sheet No. 77
For Service Bridge Plan and Details, see Sheet No. 73 thru 76
Figures in hexagons indicate item numbers under which payment will be made.
For Inlet and Outlet Channel concrete details see Sheet Nos. 28, 29 and 61.

SCALE 1" = 20'

SCALE: 1" = 50'

REVISION	DATE	DESCRIPTION	BY
1	3/25/58	Location of Intake Tower, Serv. Bridge & Stations changed.	RE
2	4-5-57	Notes revised. Note added. Drain holes revised No. 2	RE

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS.

DESIGNED BY	DR. BY	CK. BY
M.Z.	J.A.M.	K.E.

PROJECT ENGINEER

SUBMITTED BY
CHIEF, ENG. DIV.

APPROVED
CHIEF ENGINEERING DIV.

APPROVED
DIVISION ENGINEER

CONNECTICUT RIVER FLOOD CONTROL

BALL MOUNTAIN DAM

OUTLET WORKS AND SPILLWAY

PLAN AND SECTIONS

WEST RIVER VERMONT

DATE FEB. 1957

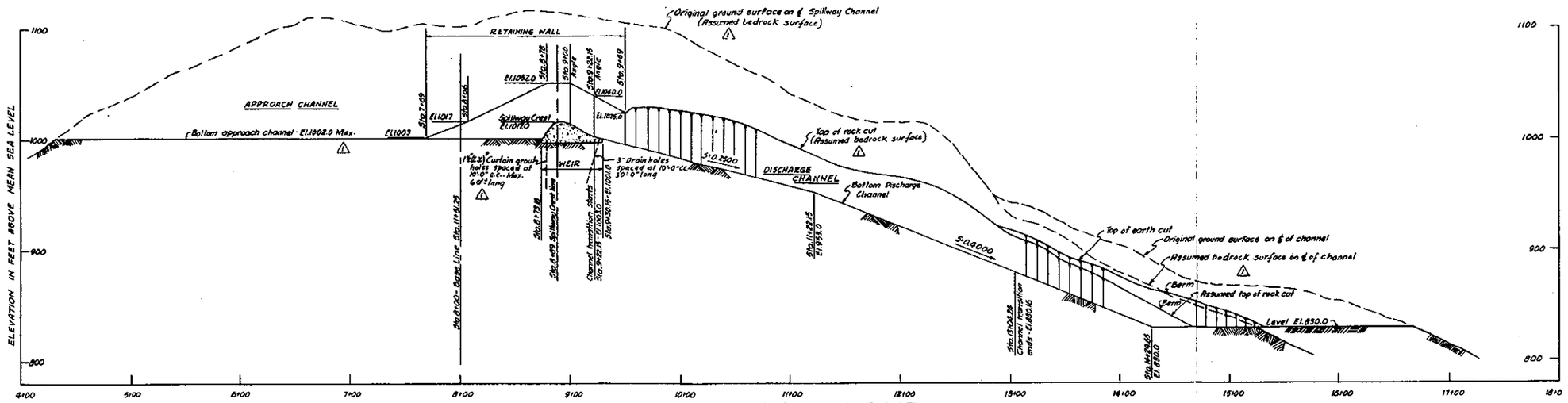
SCALE AS SHOWN | SPEC. NO. CIV. ENG. 19-020-57-73

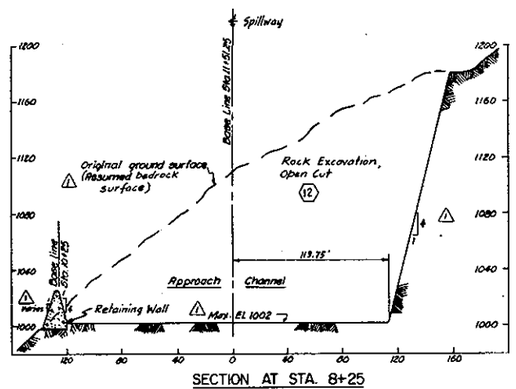
DRAWING NUMBER
CT-1-4176

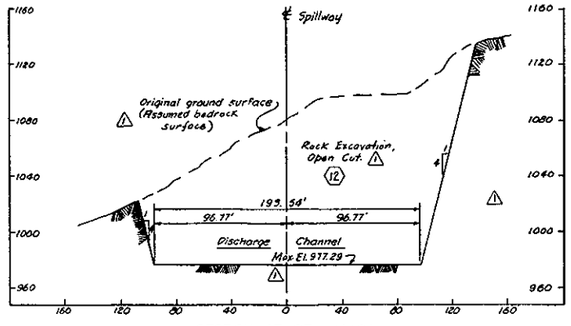
PLATE NO. II-4

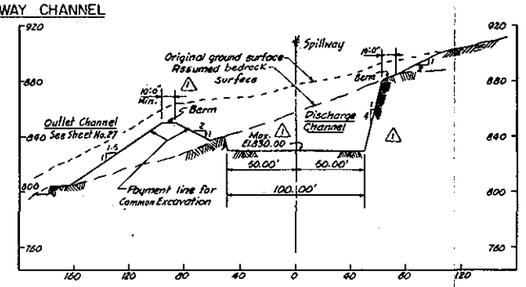
CORPS OF ENGINEERS

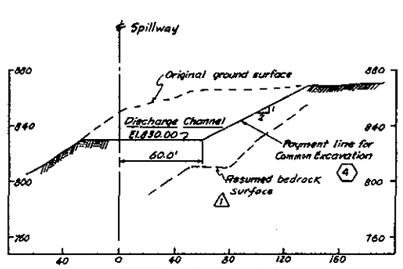
U. S. ARMY

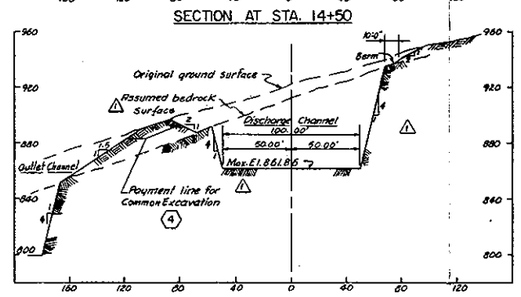


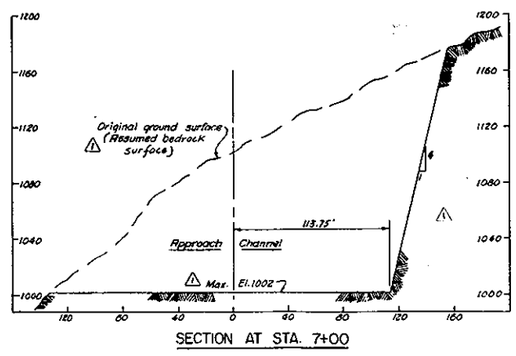


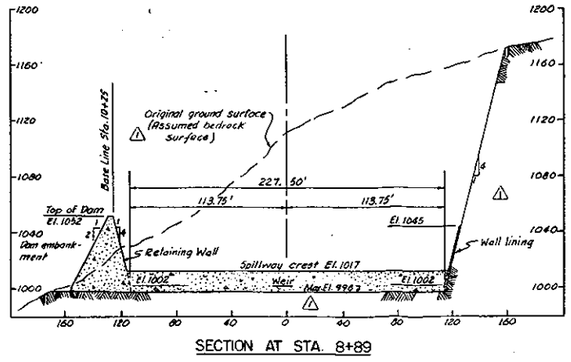


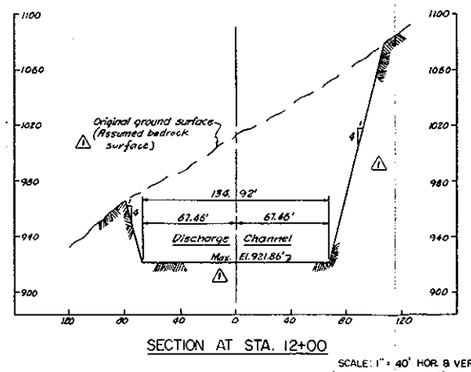












SCALE: 1" = 40' HOR. & VERT.

NOTES:

Elevations refer to Mean Sea Level Datum.
Figures in hexagons indicate the item numbers under which payment will be made.
For general notes applying to this sheet see Sheet No. 23

REVISION	DATE	DESCRIPTION	BY
1	3/20/57	Slope designation corrected. Notes revised, dashed. Add'l.	

CORPS OF ENGINEERS, U. S. ARMY
OFFICE OF THE DIVISION ENGINEER
NEW ENGLAND DIVISION
BOSTON, MASS

DES. BY	DR. BY	CK. BY
M.E.	T.O.B.	M.S.

CONNECTICUT RIVER FLOOD CONTROL
BALL MOUNTAIN DAM
SPILLWAY
CHANNEL SECTIONS
WEST RIVER VERMONT

SUBMITTED BY: PROJECT ENGINEER
APPROVED: CHIEF, ENGINEERING BRANCH
APPROVED: CHIEF ENGINEERING DIV.
APPROVED: LT. COL. C.E. ASST. DIVISION ENGINEER
DATE FEB. 1957

SCALE: AS SHOWN | SPEC. NO. CIV. ENG. 19-026-57-72

DRAWING NUMBER CT-1-4177

PLATE NO. 11-5

A T T A C H M E N T III

TOWNSHEND DAM AND RESERVOIR

WEST RIVER, VERMONT

ATTACHMENT III

TABLE OF CONTENTS

LIST OF PLATES

Plate No.	Title
III-1	General Development Plan
III-2	General Plan
III-3	Embankment Sections
III-4	Spillway and Outlet Works
III-5	Spillway Profile
III-6	Outlet Works Profile

PERTINENT DATA
TOWNSHEND DAM AND RESERVOIR
WEST RIVER, VERMONT

DRAINAGE AREA (square miles)	Total - 278 Net - 106
RESERVOIR	
Permanent Pool	
Elevation (feet msl)	478
Capacity (acre-feet)	800
Inches Runoff	0.14
Percent of Total Storage	2
Area (acres)	95
Flood Control Storage	
Capacity (acre-feet)	32,800
Inches Runoff for Net Area	5.81
Area - Spillway Crest (acres)	735
DAM	
Type	Rolled earth and rockfill
Length (feet)	1,700
Top Elevation (feet msl)	583
Maximum Height (feet)	133
SPILLWAY	
Type	Side channel concrete ogee
Length (feet)	439
Crest Elevation (feet msl)	553
OUTLET WORKS	
Type	Horseshoe conduit
Conduit Size	20'6" diameter
Length (feet)	360
Capacity - Spillway Crest (cfs)	21,600
Gates	Three 7.5' x 17.0'

SPILLWAY DESIGN FLOOD	
Inflow (cfs)	228,000
Outflow (cfs)	224,000
Maximum Surcharge (feet)	25
PROJECT COST	$7,320,000
PLACED IN OPERATION	March 1961
MAINTAINED BY	NED

ATTACHMENT III
TOWNSHEND DAM AND RESERVOIR
WEST RIVER, VERMONT

1. AUTHORITY

Townshend Dam and Reservoir is a unit of the comprehensive plan for flood control in the Connecticut River basin. Authorization is contained in the Flood Control Act of 1938 (Public Law 761, 75th Congress, 3rd Session) as modified by the Flood Control Act of 1941 (Public Law 228, 77th Congress, 1st Session) and the Flood Control Act of 1944 (Public Law 534, 78th Congress, 2nd Session). Construction of the project was initiated in October 1958 and completed in June 1961.

2. PROJECT LOCATION

The Townshend Dam and Reservoir is located on the West River in the township of Townshend, Windham County, Vermont. It is in the southeastern part of the state about 19.5 miles upstream of the confluence of the Connecticut and West Rivers at Brattleboro, Vermont and 22 miles north of the Massachusetts state line.

3. DESCRIPTION OF PROJECT

Major project components consist of a rolled earth and rockfill dam, side channel spillway and an outlet works. At spillway crest Townshend Reservoir has a capacity of 33,600 acre-feet, which is equivalent to 6 inches of runoff from the drainage area of 106 square miles below Ball Mountain Dam. When filled to spillway crest, the reservoir is about 4.5 miles long with a surface area of about 735 acres. A reservoir map of Townshend Dam is shown on Plate No. III-1.

a. Dam. The dam consists of rolled earth and rockfill embankment 1,700 feet long with a maximum height of 133 feet (Plate Nos. III-2 and III-3). The top of dam at elevation 583 feet msl provides for 25 feet of surcharge and 5 feet of freeboard. The top width of the dam is 25 feet with side slopes at 1 on 2.0 to 1 on 2.5.

b. Spillway. The side channel spillway is located on the left abutment adjacent to the dam. The side channel spillway is an uncontrolled ogee weir with a fixed crest at elevation 553 feet msl

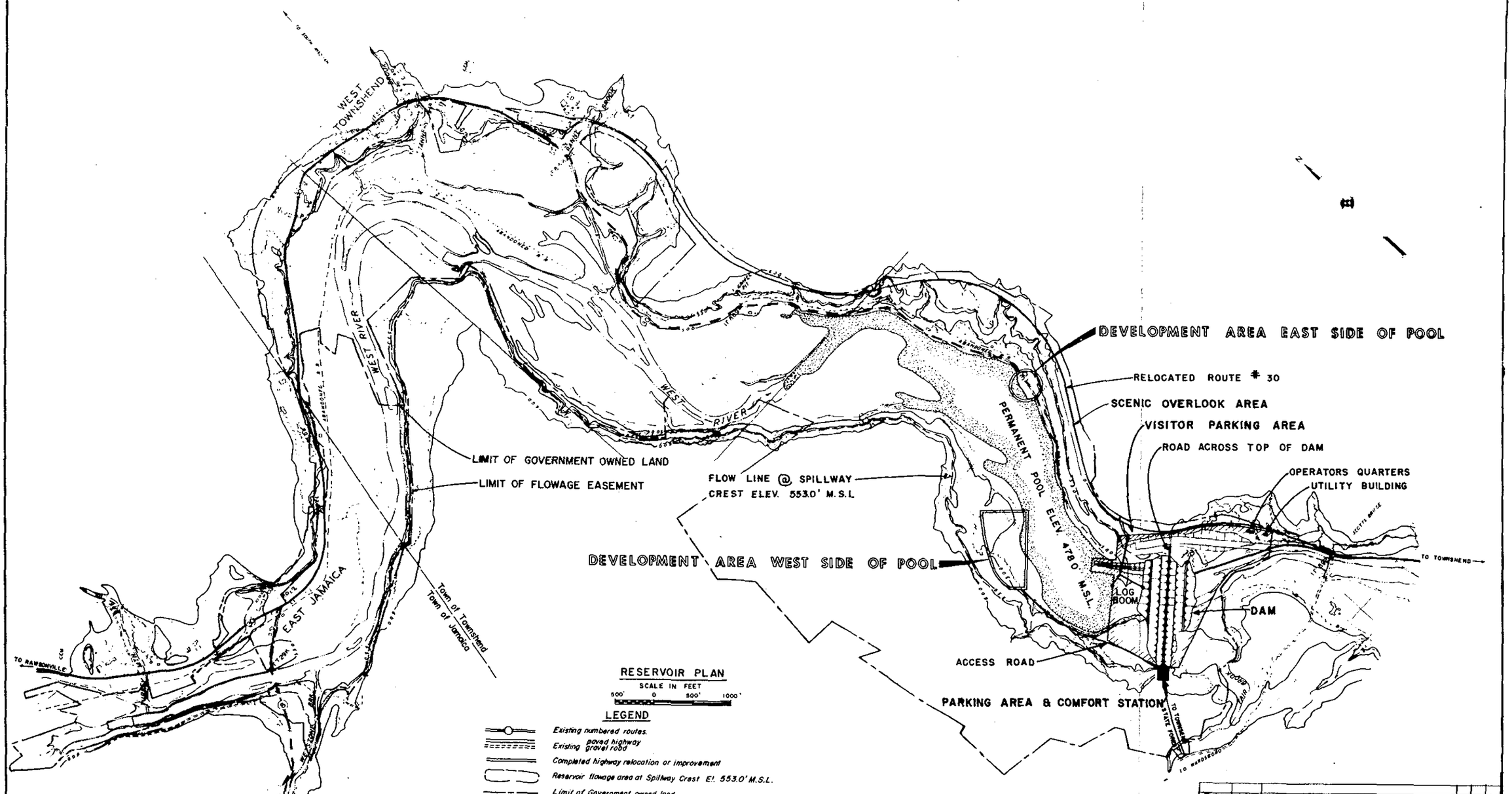
and a length of 439 feet. The spillway discharge channel has a constant bottom width of 70 feet with invert slopes at 0.09, 0.04 and 0.008. A plan and profile of the spillway is shown on Plate Nos. III-4 and III-5.

c. Outlet works. The outlet works shown on Plate Nos. III-4 and III-6 consist mainly of an intake structure, a horseshoe conduit and an outlet channel. The intake structure houses the equipment necessary to operate the three 7.5' x 17' gates that control the flow in the conduit. A conservation pool is maintained at elevation 478 by an outlet weir in front of the center gate. The conduit, comprised of a concrete horseshoe tunnel 20.5' in diameter, is 540 feet long and slopes at 0.0057. At the end of the horseshoe conduit, the outlet works flare to the outlet channel which has a constant bottom width of 50 feet and a level bottom at elevation 454 feet msl until it empties into the West River.

d. Recreation. A U-shaped weir at the entrance of the center gate creates a 100-acre permanent pool at elevation 478 feet msl for recreational purposes. Principal recreational activities at Townshend Reservoir are swimming, picnicking, small boating and fishing. The reservoir designated for recreational use is shown on Plate No. III-1.

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



RESERVOIR PLAN

SCALE IN FEET

500' 0 500' 1000'

LEGEND

- Existing numbered routes.
- Existing paved highway
- Existing gravel road
- Completed highway relocation or improvement
- Reservoir flowage area at Spillway Crest El. 553.0' M.S.L.
- Limit of Government owned land
- Limit of flowage easement
- Area reserved for project operation

NOTE

PREPARED FROM SHEETS NO 10, 11, AND 12 OF THE WILLIAMSVILLE AERIAL SURVEY (FILE NOS. CT-5-1530, 1531 AND 1532).

REVISION	DATE	DESCRIPTION

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DES. BY	DR. BY	CK. BY
WFM-C	E.J.K.	H.D.P.

SUBMITTED BY: CHIEF, WATER CONTROL SECTION

APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION

APPROVED: CHIEF OF ENGINEERS

CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND RESERVOIR
MASTER PLAN
GENERAL DEVELOPMENT PLAN
WEST RIVER VERMONT

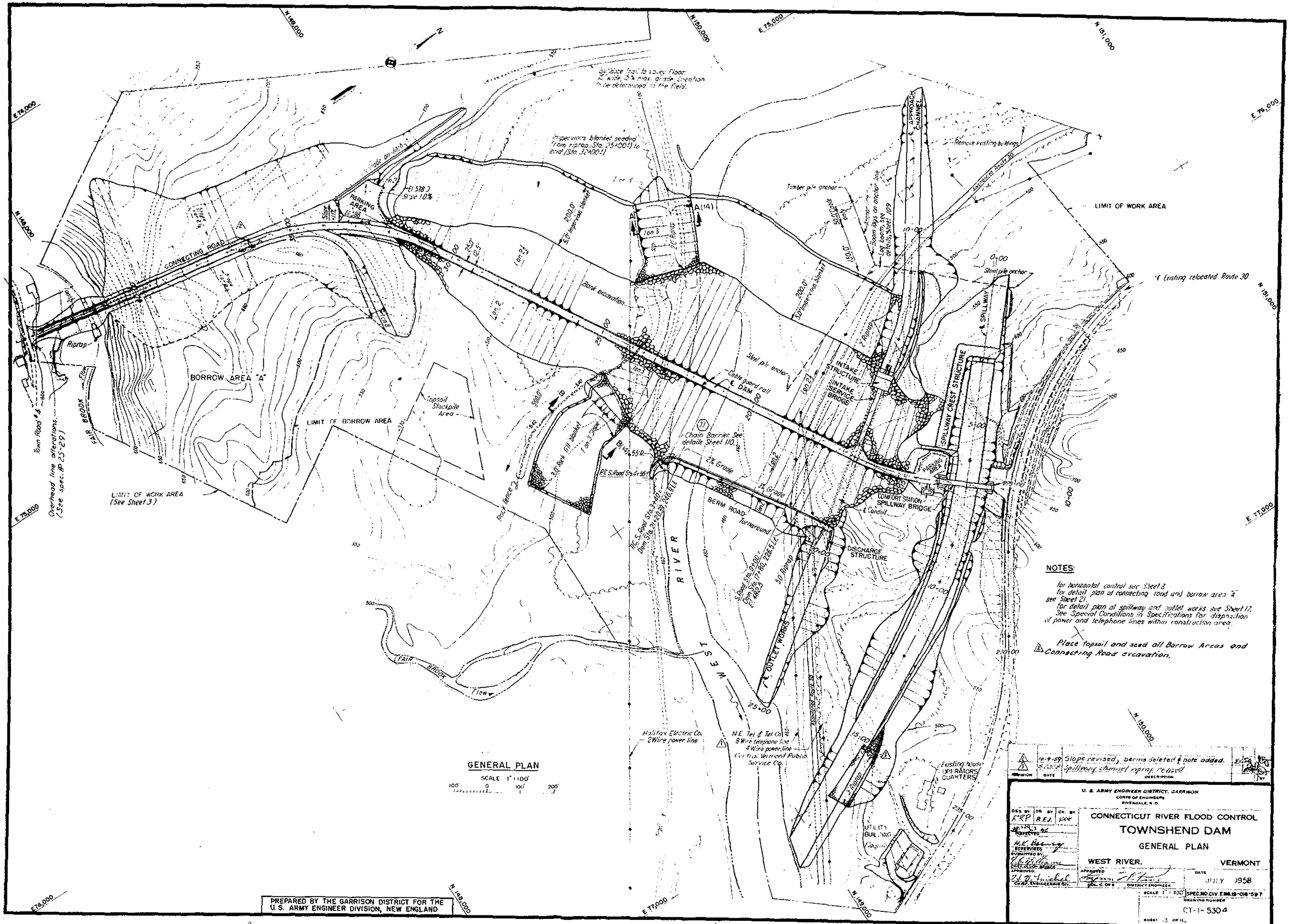
DATE MARCH 1961

SCALE 1" = 500'

DRAWING NUMBER
CT-1-5670

SHEET 3 OF 10

PLATE NO. III-1



GENERAL PLAN

SCALE 1" = 100'

NOTES:

For horizontal control see Sheet 3.
For detail plan of connecting road and borrow area "A" see Sheet 21.
For detail plan of spillway and outlet works see Sheet 17.
See Special Conditions in Specifications for disposition of power and telephone lines within construction area.

△ Place topsoil and seed all Borrow Areas and Connecting Road excavation.

△	10-9-59	Slope revised, berms deleted & note added.
△		Spillway channel riprap revised

U. S. ARMY ENGINEER DISTRICT, GARRISON
CORPS OF ENGINEERS
RIVERDALE, N.D.

CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND DAM
GENERAL PLAN
WEST RIVER, VERMONT

JULY 1958

SCALE 1" = 100' SPEC. NO. CIV-ENG-19-016-59-7

CT-1-5304

PREPARED BY THE GARRISON DISTRICT FOR THE U. S. ARMY ENGINEER DIVISION, NEW ENGLAND

PLATE NO. III-2

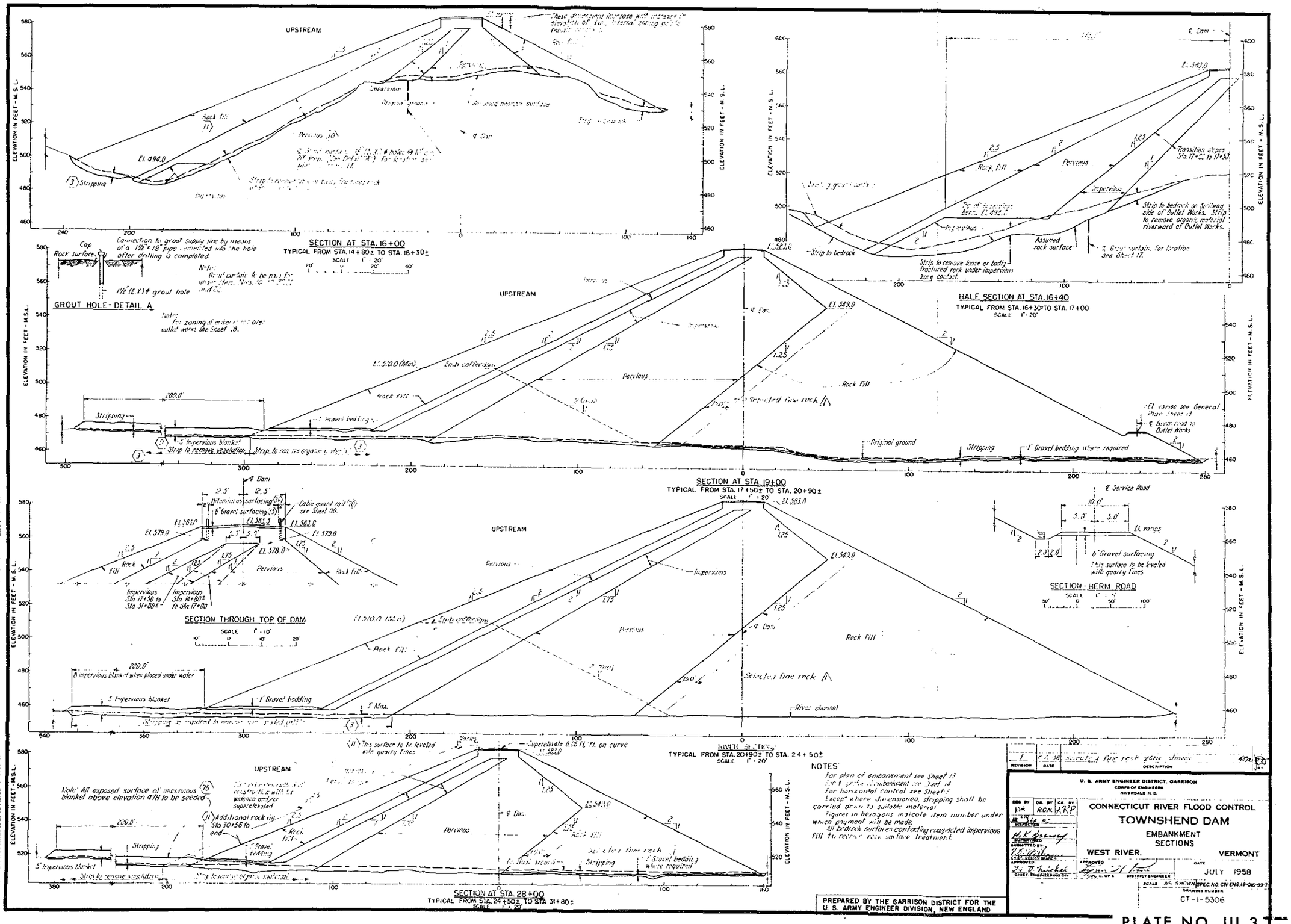
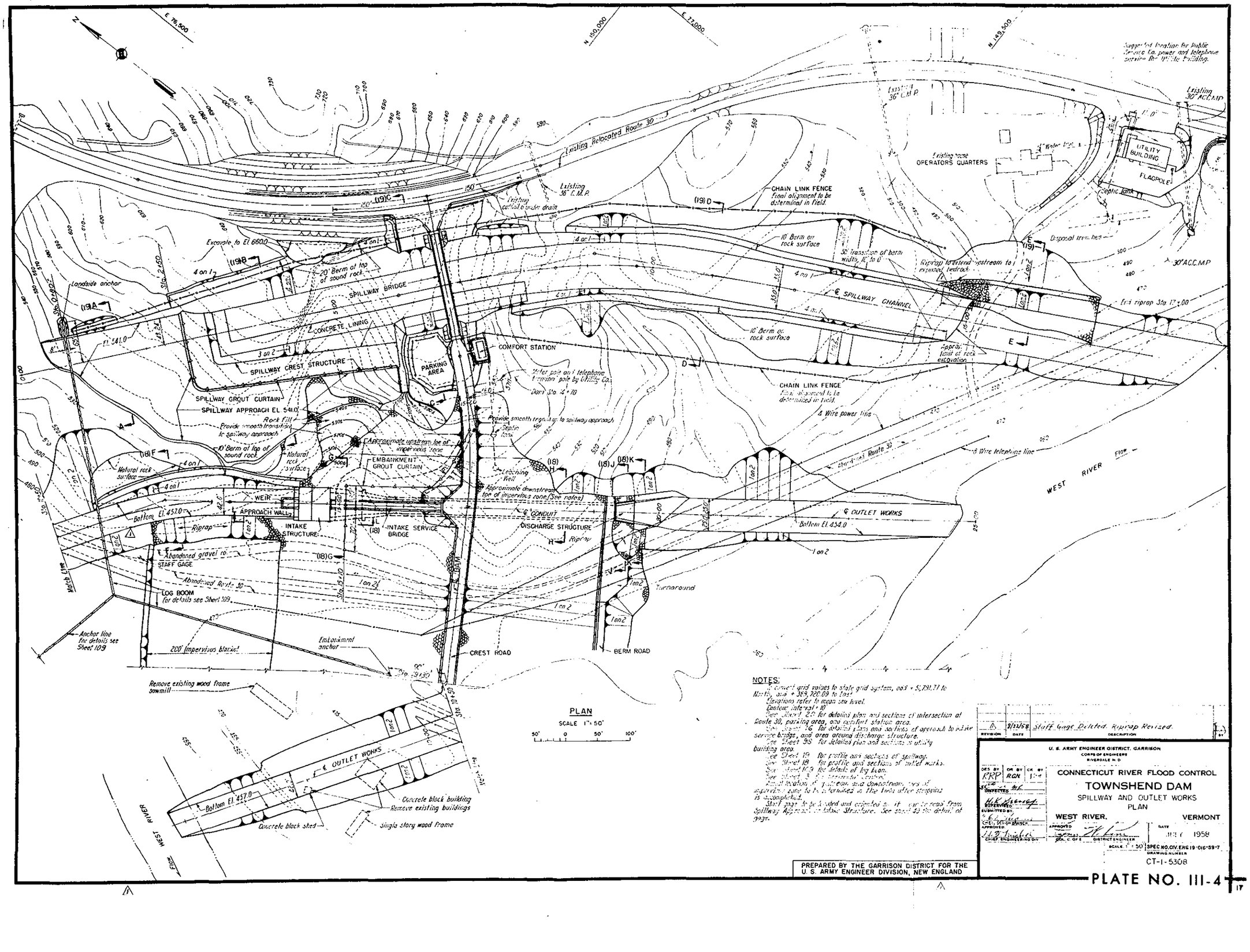


PLATE NO. III-3



NOTES:

1. Convert grid values to state grid system, add + 5,791.71 to North, add + 389,720.09 to East.
2. Elevations refer to mean sea level.
3. Contour interval = 10
4. See Sheet 2.0 for detailed plan and sections of intersection of Route 30, parking area, and comfort station area.
5. See Sheet 16 for detailed plans and sections of approach to intake service bridge, and area around discharge structure.
6. See Sheet 99 for detailed plan and sections of utility building area.
7. See Sheet 19 for profile and sections of spillway.
8. See Sheet 18 for profile and sections of outlet works.
9. See Sheet 109 for details of log boom.
10. See Sheet 3.0 for remedial control.
11. Final location of upstream and downstream toes of impervious zone to be determined in the field after stripping is accomplished.
12. Sheet page to be located and oriented so it can be read from Spillway Approach or Intake Structure. See sheet 43 for detail of page.

NO.	DATE	REVISION
1	9/15/58	Staff Gage Deleted. Riprap Revised.

PREPARED BY THE GARRISON DISTRICT FOR THE U. S. ARMY ENGINEER DIVISION, NEW ENGLAND

U. S. ARMY ENGINEER DISTRICT, GARRISON
CORPS OF ENGINEERS
RIVERDALE N. D.

DES. BY RRP | DR. BY RGN | CK. BY

SUPERVISED BY
SUBMITTED BY
CHIEF, DIV. OF BRANCH
APPROVED
CHIEF ENGINEERING DIV.

APPROVED
CHIEF, DIV. OF ENGR.
DISTRICT ENGINEER
DATE JUL 1958

CONNECTICUT RIVER FLOOD CONTROL
TOWNSHEND DAM
SPILLWAY AND OUTLET WORKS
PLAN
WEST RIVER, VERMONT

SCALE 1" = 50' | SPEC. NO. CIV. ENG 19-016-59-7
DRAWING NUMBER
CT-1-5308

PLATE NO. III-4

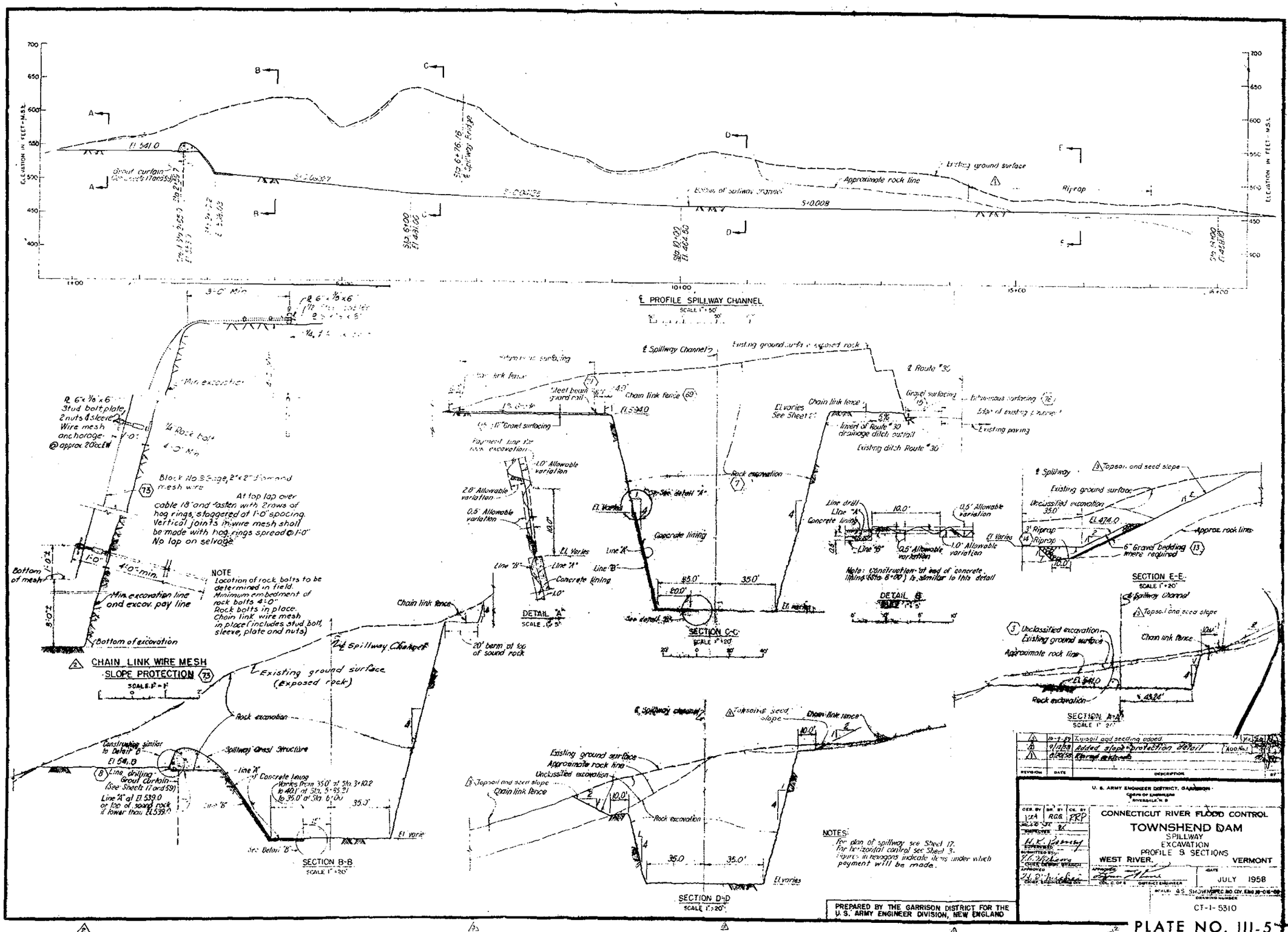
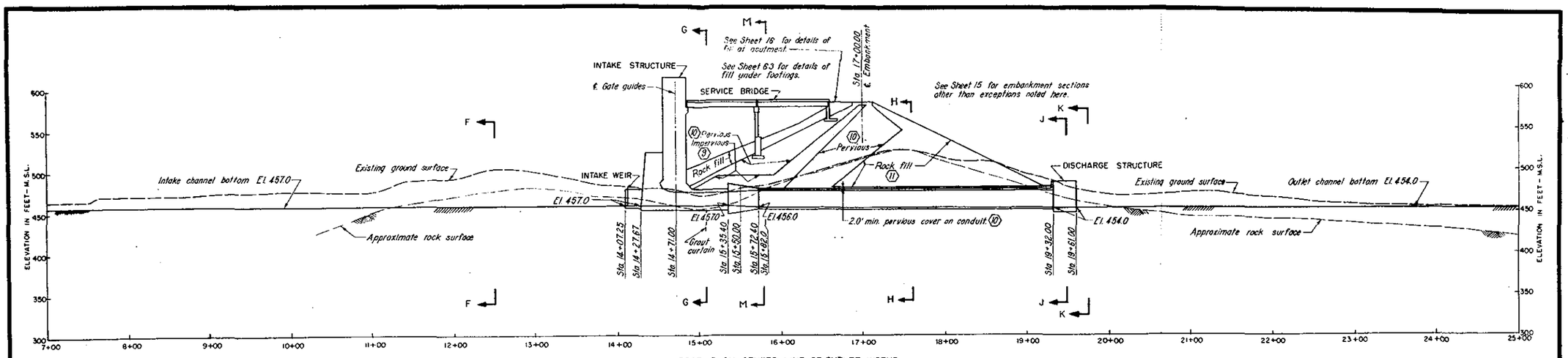
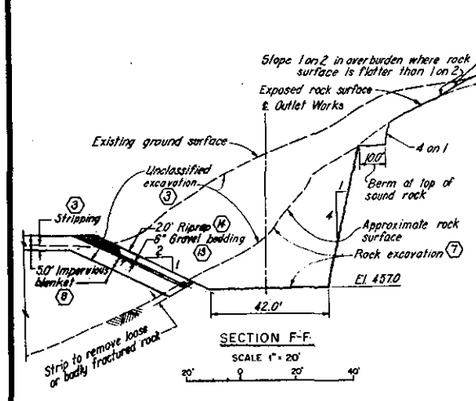


PLATE NO. III-5



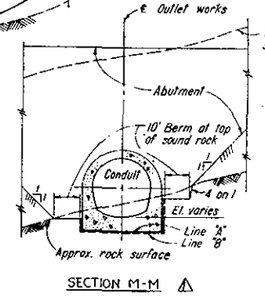
PROFILE ON CENTER LINE OF OUTLET WORKS

SCALE 1"=50'



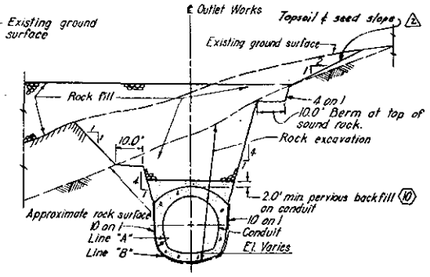
SECTION F-F.

SCALE 1" = 20'



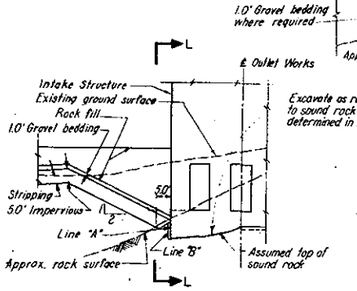
SECTION M-M

SCALE 1" = 20



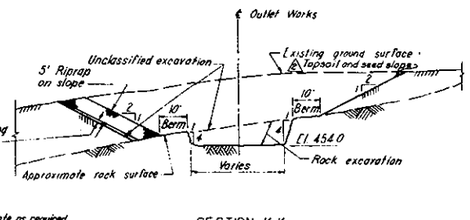
SECTION H-H

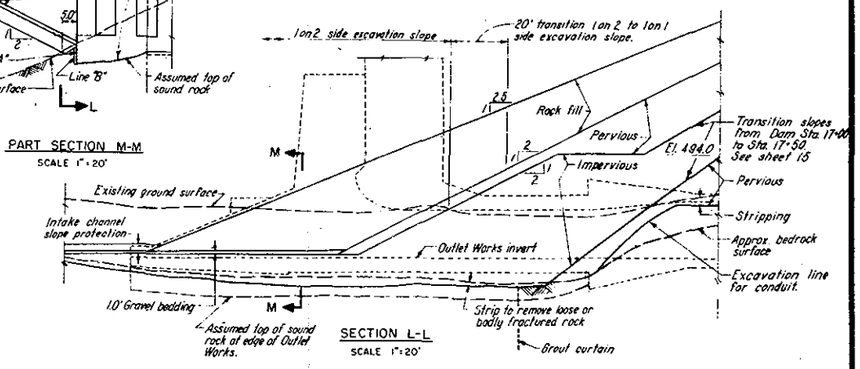
SCALE 1"=20'



SECTION K-K

SCALE 1"=20'



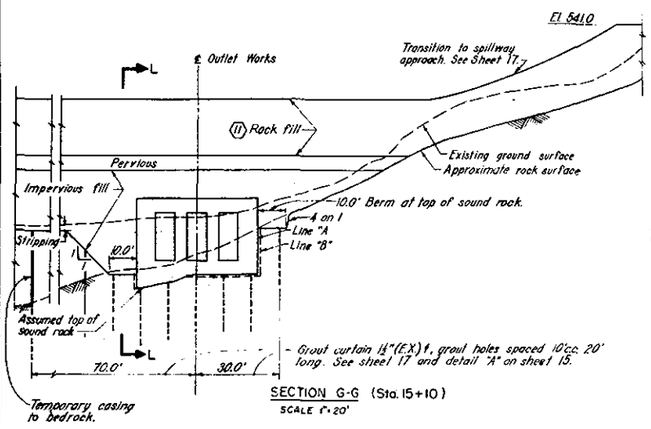


PART SECTION M-M

SCALE 1" = 20'

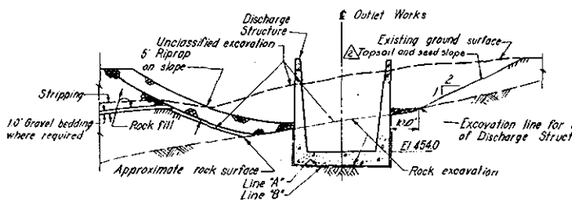
SECTION L-L

SCALE 1"=20'



SECTION G-G (Sta. 15+10)

SCALE 1"=20'



SECTION J-J

SCALE 1"=20'

NOTES:

For plan of outlet works see Sheet 17
For horizontal control of outlet works see Sheet 3
Figures in hexagons indicate item numbers under which payment will be made.
Line "A" represents minimum required section.
Line "B" is pay line for excavation and backfill.
For dimensions on concrete structures, see structural details.
For location of section L-L see Sheet 17
All rock surfaces contacting compacted impervious fill to receive first surface treatment.

REVISION	DATE	DESCRIPTION
2	10-9-58	Topsoil & seeding added.
1	9-20-58	Conduit section designation changed

U. S. ARMY ENGINEER DISTRICT, GARRISON
CORPS OF ENGINEERS
RIVERDALE, N. D.

DES. BY	DR. BY	CH. BY
KRP	H.A.Z.	WK

CHIEF, DESIGN BRANCH

CHIEF, ENGINEERING DIV.

CONNECTICUT RIVER FLOOD CONTROL

TOWNSHEND DAM

OUTLET WORKS
EXCAVATION & FILL
PROFILE & SECTIONS

WEST RIVER, VERMONT

APPROVED

COL. C. OF E. DISTRICT ENGINEER

DATE JULY 1958

SCALE: AS SHOWN SPEC. NO. CIV. ENG. 19-065-58-7

DRAWING NUMBER CT-1-5309

SHEET 18 OF 110

PREPARED BY THE GARRISON DISTRICT FOR THE U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

PLATE NO. III-6

A T T A C H M E N T IV

BALL MOUNTAIN AND TOWNSHEND RESERVOIRS

DETAIL REGULATION PROCEDURES

ATTACHMENT IV

TABLE OF CONTENTS

LIST OF PLATES

ATTACHMENT IV
BALL MOUNTAIN AND TOWNSHEND RESERVOIRS
DETAIL REGULATION PROCEDURES

1. PURPOSE

This attachment prescribing the regulation of Ball Mountain and Townshend Reservoirs during nonflood and flood periods is for the use of the Reservoir Regulation Section (RRS) and the operators at the West River dams. It will be in effect until regulation experience indicates need for revision.

2. GENERAL

Ball Mountain and Townshend Reservoirs will be regulated for flood stage reductions along the West River and, in combination with other tributary reservoirs, for downstream communities on the Connecticut River. In general, regulation of Ball Mountain and Townshend Reservoirs will follow specific instructions from the Reservoir Regulation Section unless there is failure of communications and prompt regulation is required.

3. ORGANIZATION

Ball Mountain and Townshend Dams are classified as "paired dams," i.e. those dams located nearby in the same watershed which should be operated together at all times. Townshend Dam is considered the primary paired dam whose operator is responsible for receiving data and relaying instructions to the operator of the secondary paired dam (Ball Mountain) whenever contact with the RRS must be made by telephone. Pertinent information is transmitted to the RRS by telephone whenever contact cannot be made via the NED Radio Network or when NED headquarters are not manned. In his absence, the Ball Mountain operator will relay the pertinent information. Under normal circumstances when the RRS can be contacted by radio, the respective operators will relay their own information.

The Townshend operator is also responsible for the coordinated regulation of both dams in cases of emergency when regulation is required and contact cannot be made with the RRS either by radio or telephone. Paragraph 9, Emergency Operation Procedures (EOP), prescribes the regulation of the dams when the RRS cannot be contacted.

Whenever circumstances require operation of the dams and contact cannot be made between the dams or the RRS, the respective dams are to be operated in accordance with the EOP, and the Ball Mountain operator is to drive to Townshend Dam to relay pertinent information.

4. RESERVOIR REGULATION - NORMAL PERIODS

a. Nonfreezing season.

(1) Ball Mountain Reservoir. All 3 gates will be maintained at 3-foot openings.

(2) Townshend Reservoir. A permanent pool will be maintained for recreational uses at a stage of about 22 feet. The crest of the permanent U-shaped weir at the entrance to the center gate is elevation 478.0 feet msl, equivalent to a stage of 21 feet. Normally, the 2 outside gates will be closed and the middle gate fully opened. During minor rises the 2 outside gates will be operated according to the following schedule in order to minimize pool stage fluctuation.

GATE OPERATION SCHEDULE FOR
MAINTENANCE OF RECREATION POOL

	Gate Opening (feet)		
Pool Stage (Rising)	#1	#2	#3
21	0	F	0
23	1	F	1
24	2	F	2
25	3	F	3
26	4	F	4
27 and higher	See paragraph 5 - Flood Regulation		

Pool Stage (Falling)

Leave gates at last setting until pool recedes to 22 feet, then lower both outside gates by 1-foot increments until pool stabilizes below 22 feet.

b. Freezing season.

(1) Ball Mountain Reservoir. Commencing about 1 December, the outside gates will be closed and the center gate will be throttled in order to maintain a winter pool between stages of 13 and 20 feet. The winter pool will be developed gradually with some water being released continually. The pool will be emptied in late March or early April upon instructions from the Reservoir Regulation Section.

(2) Townshend Reservoir. Commencing about 1 December, the pool level will be maintained at a stage of 23 to 25 feet by operation of one outside gate. The center gate and one of the outside gates will be fully closed. The pool will be returned to the normal level in late March or early April upon instructions from the Reservoir Regulation Section.

c. Thawing season.

(1) Ball Mountain Reservoir. About 15 March, upon instructions from the Reservoir Regulation Section, the winter pool will be emptied and the 3 gates will be opened 3'-3'-3'. During this period reports will be made as requested by the Reservoir Regulation Section.

(2) Townshend Reservoir. About 15 March, upon instructions from the Reservoir Regulation Section, the winter pool will be drawn down to a stage of about 15 feet, the center gate opened fully, and the side gates opened to satisfy the rate of inflow. During this period reports will be made as requested by the Reservoir Regulation Section.

5. RESERVOIR REGULATION - FLOOD PERIODS

Regulation of flow from Ball Mountain and Townshend Reservoirs may be considered in three phases during the course of a flood: Phase I, the storm and runoff appraisal leading to the initial regulation during the development of the flood; Phase II, regulation during the flood period; and Phase III, emptying the reservoir following the downstream recession of the flood. The following paragraphs describe the methods of regulation during these various phases.

a. Phase I - Initial regulation of flow. Phase I is the most critical since it is necessary to collect rainfall and discharge data and to promptly recognize and appraise the development and

magnitude of the flood in a short period of time. Gate operations at Ball Mountain and Townshend Dams are initiated for river stages on the West and Connecticut Rivers and also for rainfall over the basin.

(1) West River. Ball Mountain and Townshend Reservoir outflows will be restricted as necessary to maintain safe channel capacities on the West River. High river stages would be produced by runoff from rainfall, snowmelt or a combination thereof. Safe channel capacities are as follows:

Location	Safe Channel Capacity (cfs)	Stage At	(feet)
Ball Mountain to Townshend	4,000	Jamaica	8.5
Townshend to Newfane	7,000	Newfane	9.0
Newfane to Dummerston	10,000	Dummerston	344.0

Plate No. IV-2 contains forecast curves of rainfall vs. Newfane discharges assuming no contribution from Townshend Dam. Also included is the relationship between Newfane and Dummerston discharges.

Townshend Dam will be regulated to minimum gate openings ($10\frac{1}{2}$ cfs) when the Newfane stage reaches 8 feet (4,800 cfs) and rising. Discharges from Ball Mountain Dam shall be less than those from Townshend and restricted so as to provide more available net storage at Townshend Reservoir than at Ball Mountain (see paragraph 5c).

(2) Connecticut River. Regulation of the reservoirs for Connecticut River stages would be based on the origin of the storm and in accordance with the following schedule:

Storm Origin	Regulation Required
Upstream (North of Wilder)	No regulation until crest reaches White River Junction.
Central (Wilder to North Walpole)	Restrict outflow at dams and be prepared to close to minimum openings. A regulation schedule is as follows:

Index Location	Stage for Initiating Regulation	Regulation Required
North Walpole	24.0 feet (66,700 cfs), rising	3,000 cfs discharge
North Walpole	25.0 feet (71,200 cfs), rising	1,500 cfs discharge
North Walpole	26.0 feet (75,700 cfs) and higher	Minimum opening*

* Minimum required for maintenance of fish life (10½) cfs

Storm Origin	Regulation Required
Downstream (South of North Walpole)	Restrict outflow based on local conditions and be prepared to close to minimum openings according to the following schedule:

Index Location	Stage for Closing Gates to Minimum Openings
North Walpole	26.0 feet (75,700 cfs)
Montague City	25.0 feet (65,800 cfs)
Springfield	12.0 feet (65,000 cfs)

Table 1 consists of a Flood Warning and Emergency Operation Guide for Connecticut River stages. Included in the table are tabulated warning stages, flood stages, average peak travel time and maximum recorded stages.

(3) Rainfall. Past experience has indicated that 2 inches of rainfall over the West River basin in 24 hours will produce a moderate rise in river stages. Therefore, initial regulation of the reservoirs is also considered necessary whenever the following rainfall has been recorded at either dam within the 24-hour period.

Rainfall-Inches (24-hour period)	Maximum Permissible Discharge	
	Ball Mountain (cfs)	Townshend (cfs)
Less than 2	Gates in normal position	Gates in normal position
2 to 3	2,000	3,000
3 to 4	1,000	1,500
More than 4	10 (min. opening)	10 (min. opening)

Phase I terminates when gates at the dams are operated to restrict the reservoir outflows.

b. Phase II - Continuation of regulation. During this phase of a flood the outflows from the reservoirs are regulated to alleviate, or reduce as far as practicable, downstream flood damages on the West and Connecticut Rivers. If the gates are completely closed, they remain in this position until the final phase of operation is initiated and emptying of the stored runoff may begin.

(1) West River. The dams will be regulated to maintain safe channel capacities on the West River. If some outflow is being released, further gate operations may be necessary as the reservoirs rise in order to maintain nondamaging flows.

(2) Connecticut River. For Connecticut River stages, the dams are regulated in coordination with other reservoirs in the system to desynchronize West River contributions to Connecticut River flood peaks whenever necessary to reduce flood stages. Table 1 presents flood stages at principal index stations on the Connecticut River.

TABLE I

FLOOD WARNING AND EMERGENCY OPERATION GUIDE
CONNECTICUT RIVER BASIN

Index Station	Warning Stage (gage height in feet)	Flood Stage & Discharge (gage height in feet)	(cfs)	Ave. Peak Travel Time (hours)	Max. Recorded Stage (gage height in feet)	(date)
White River Junction	17.0 (38,300)	20.0	51,000		35.0	11/ 4/27
North Walpole	26.0 (75,700)	30.0	95,000	9	43.8	3/19/36
Montague City	25.0 (65,800)	28.0	80,000	20	49.2	3/19/36
Holyoke	7.0 (60,000)	9.0	92,000	12	16.8	3/19/36
Springfield	12.0 (65,000)	20.0	151,000	6	28.6	3/20/36
Thompsonville	8.0 (120,000)	10.3	161,700	6	16.6	3/20/36
Hartford	16.0 (66,000)	22.0	114,000	7	37.6	3/21/36

Another important regulation activity during this period is the collection of hydrologic and hydraulic data such as (a) precipitation amounts throughout the entire West River basin; (b) snow cover and water content in case of a spring flood; (c) stage and discharge values at downstream control points on the West River; and (d) any other pertinent rainfall and runoff information which will assist in the regulation of the reservoirs. Discharge data along the main Connecticut River and principal tributaries above and below the mouth of the West River are collected by the RRS in order to coordinate the regulation of Ball Mountain and Townshend Reservoirs with all other reservoirs in the Connecticut River basin.

c. Phase III - Emptying the reservoirs. Phase III is usually based on Connecticut River conditions. Following recession of the flood on the West and Connecticut Rivers, the reservoirs are emptied as rapidly as possible.

(1) West River. Evacuation discharges from the reservoirs will not exceed West River channel capacities listed in paragraph 5a(1). The rate of discharge to be released from Townshend Reservoir depends primarily on the stage at Newfane and is restricted to the channel capacity of 7,000 cfs. The rate of discharge from Ball Mountain Reservoir is related to that of Townshend Reservoir and restricted to the channel capacity of 4,000 cfs. Whenever discharge from Townshend Reservoir is restricted due to downstream conditions, allowable outflow from Ball Mountain is determined from available storage in the two reservoirs and the outflow from Townshend Reservoir in accordance with the following formula:

$$Q_2 = .6 \left(\frac{S_1}{S_2}\right) Q_1$$

where Q_2 = permissible discharge from Ball Mountain Reservoir

S_1 = available storage in inches at Townshend Reservoir

S_2 = available storage in inches at Ball Mountain

Q_1 = discharge from Townshend

Q_2 shall not exceed 4,000 cfs except under extraordinary conditions and specific directions by the Reservoir Regulation Section. Guide curves depicting the above formula for allowable Ball Mountain releases are shown on Plate No. IV-3.

(2) Connecticut River. Evacuation of the reservoirs will not be initiated until the flood crest has passed Montague City. Guide cuves for West River reservoir releases are shown on Plate No. IV-3A. In general, the following rule for evacuation will apply when stages at Montague City reach the following conditions:

Storage Used at Ball Mountain and Townshend (percent)	Evacuation Stages
50	26 feet and falling
60	28 feet and falling
70	30 feet and falling
80	32 feet and falling
90	34 feet and falling
100	36 feet and falling

Evacuating discharge from the West River reservoirs will be coordinated with releases from other projects in the system in a manner that will allow Connecticut River flood crests to continue to recede. This subject will be described in detail in the Master Regulation Manual.

The rate of increase in reservoir discharge during the emptying period is not to exceed 1,000 cfs per hour at either dam. The Townshend FCDO will advise the Central Vermont Public Service whenever high release rates of flow are proposed so that they will have the opportunity to remove the flashboards at West Dummerston Dam. Secondary river rises during Phase III or even Phase II, due to either additional rainfall or snowmelt, may result in the regulation procedure reverting to Phase I.

d. Spillway discharge. Ordinarily during a major flood, the gates will not be opened to avoid spillway discharge. Surcharge storage above the elevation of the spillway crest will be utilized whenever the downstream channel capacity continues to be exceeded by the runoff from uncontrolled areas. However, the gates at the dam will be immediately operated with or without instructions from RRS when their respective pools reach the following levels.

BALL MOUNTAIN DAM AND RESERVOIR

Pool Stage (feet)	Operation Required
226.5 (15' above spillway crest)	1 gate fully open
231.5 (20' above spillway crest)	2 gates fully open
236.5 (25' above spillway crest)	3 gates fully open

TOWNSHEND DAM AND RESERVOIR

Pool Stage (feet)	Operation Required
106.0 (10' above spillway crest)	1 gate fully open
111.0 (15' above spillway crest)	2 gates fully open
116.0 (20' above spillway crest)	3 gates fully open

All residents within the reservoir area or downstream on the West River that may be affected during an extreme flood, will be advised immediately whenever high surcharge stages or excessive spillway discharges are occurring or anticipated.

e. Minimum discharge.

(1) Ball Mountain Reservoir. Unless local inflow from brooks downstream of the dam is adequate, sufficient flow will be discharged at all times to maintain fish life in the river below the dam. A minimum discharge of approximately 10 cfs should be adequate for this purpose; however, during periods of flood regulation when reservoir outflow will be restricted, the operator should observe Cobb Brook discharge and supplement it if necessary with reservoir releases to insure that the flow in the West River will be adequate to maintain fish life.

(2) Townshend Reservoir. Sufficient flow will be maintained in the river below the dam to sustain fish life. Normally, the discharge in Fair Brook should be adequate; however, during periods of flood regulation or at other times when the reservoir

outflow is restricted, the operator should release sufficient water from the reservoir to supplement the flow if necessary.

6. RESERVOIR REGULATION - WHITE WATER CANOE RACES

a. General. At the request of the American Canoe Association the Corps of Engineers cooperates to regulate Ball Mountain Reservoir for national white water canoe races on a 3-day week end each spring on the West River at Jamaica, Vermont. It is stipulated that the races must be conducted by 20 May as natural riverflow beyond this date often recedes rapidly and holding storage from spring runoff for a later date is not desirable.

To assure ideal racing conditions, approximately 2,500 acre-feet of runoff at stage 70 (5 percent of total available reservoir space) will be stored in the reservoir and released at a steady rate according to the racing schedule and the available storage.

b. Reservoir storage. Water stored in the reservoir for canoeing purposes will approximate 2,500 acre-feet. This storage will be either residual runoff from snowmelt or storage developed in accordance with a rule curve shown on Plate No. IV-4. The rule curve developed from analyzing past discharge records at the Jamaica gage, indicates it is necessary to begin storing water about two weeks prior to the race period. The storage plus an inflow that will be equalled or exceeded 75 percent of the time will provide a desired release of 1,600 cfs for 26 hours. With no appreciable inflow, a release of 1,500 cfs could be maintained for 20 hours or 1,400 cfs for 22 hours. Officials of the national meet are considering a discharge rate of 2,000 cfs which would result in a faster depletion of the available storage.

c. Reservoir releases. A gate schedule for releasing desired flows for the races is shown on Plate No. IV-5. The recreation pool at Townshend Reservoir is lowered just prior to the canoe races in order to reregulate Ball Mountain releases during the race week end without using excessive storage. About 600 acre-feet of storage will be emptied from Townshend Reservoir, dropping the recreation pool from a stage of 22 to 10 feet. Unless high flows are occurring from concurrent storm conditions, the reregulated outflow from Townshend Reservoir will approximate 500 cfs.

7. EXTRAORDINARY FLOOD CONDITIONS

It is conceivable that extraordinary and unpredictable flood conditions may arise - such as dam or bridge failures, highway or railroad washouts, ice jams, or debris deposits. Since the prime purpose of the reservoir is to prevent further damage, regulation during such unusual conditions may not follow the previously described rules but will be governed by the urgency of the circumstances. The Reservoir Regulation Section will be notified immediately of any unusual incident so that prompt action may be taken and the gates operated to provide maximum protection.

8. REGULATION WITH FAILURE OF COMMUNICATIONS

If the flood control dam operator is unable to communicate with the Reservoir Regulation Section by normal or emergency methods and conditions develop which appear to warrant regulation, he will operate the gates in accordance with instructions contained in the Emergency Operation Procedure (paragraph 9). However, possession of instructions contained in this manual does not relieve the operator of his responsibility for continued efforts to communicate with RRS. In cases of extreme emergency, the operator shall attempt to communicate with the Reservoir Regulation Section through the Vermont State Police and the Office of Civil Defense Mobilization radio networks. It should be emphasized that whenever communications fail, and due to lack of adequate reports it is impossible to fully appraise the runoff from an intense storm, it is preferable to immediately restrict or completely stop the reservoir discharge than to delay regulation and actually contribute to downstream flood conditions.

9. EMERGENCY OPERATION PROCEDURE

Following is the Emergency Operation Procedure (EOP) to be followed by the dam operators in the event the RRS cannot be contacted. The Townshend operator has full responsibility to see that both Ball Mountain and Townshend Reservoirs are operated as prescribed below.

The Ball Mountain and Townshend operators are to close their gates immediately to minimum openings (10$\frac{1}{2}$ cfs) when the following stages are reached:

EMERGENCY OPERATION PROCEDURE
STAGES FOR COMPLETE CLOSURE OF GATES

Location	Ball Mountain (feet)	Townshend (feet)
Ball Mountain Pool	40.0	-
Jamaica	8.0	-
Townshend Pool	27.0	27.0
Newfane	-	8.0
North Walpole	-	26.0

Both dams will also be closed whenever 3 inches of rainfall has fallen in the West River basin.

Whenever contact is lost between the dams and also the RRS, the operators will be responsible for regulation of their respective dams. Gates at the dams will be closed to minimum openings when the following occurs:

Ball Mountain Dam	3" rainfall or pool stage = 40'
Townshend Dam	3" rainfall or pool stage = 27'

After regulation is made at Ball Mountain Dam, the operator will drive to Townshend Dam to relay all pertinent information.

STANDARD OPERATION PROCEDURE (S.O.P.)

BALL MOUNTAIN & TOWNSHEND DAMS

PHASE		BASIN PRECIPITATION (RAINFALL-INCHES) ANTECEDENT CONDITIONS		WEST R. INDEX STA. (STAGE IN FEET)		CONN. R. INDEX STA. (STAGE IN FEET)			RESERVOIR (STAGE IN FEET)		REGULATION INSTRUCTIONS GATE SETTINGS	
		SNOW COVERED WET OR FROZEN	DRY	JAMAICA 179 d.a. sq. mi.	NEWFANE 308 d.a. sq.mi.	NORTH WALPOLE (5493 d.a. sq. mi.)	MONTAGUE CITY 7865 d.a. sq. mi.	SPRINGFIELD 9661 d.a. sq. mi.	BALL MTN.	TOWNSHEND	BALL MTN.	TOWNSHEND
PHASE I APPRAISAL	ALERT	1.0	1.0	7.5 (2300 c.f.s.)	7.0 (2900 c.f.s.)	24.0 (66,700 c.f.s.)	22.0 (52,400 c.f.s.)		25.0	27.0	NORMAL SETTING* 3-3-3 | 0-F-0	
	CRITICAL	2.0	3.0	8.0 (3100 c.f.s.)	8.0 (4800 c.f.s.)	26.0 (75,700 c.f.s.)	25.0 (65,800 c.f.s.)	12.0 (85,000 c.f.s.)	50.0	30.0	RISTRICT OUTFLOW	
PHASE II FLOOD CONDITION		3.0	4.0	FLOOD STAGE (4,000 cfs)	FLOOD STAGE (7,200 cfs)	FLOOD STAGE (95,200 cfs)	FLOOD STAGE (80,000 cfs)	FLOOD STAGE (152,000 cfs)	——	——	0-0.2-0 | 0-0.2-0 Min. opening 10 c.f.s.	
PHASE III RECESSION	EVACUATION	STORM HAS ABATED		FOR ALLOWABLE RELEASES FROM DAMS CONSULT GUIDE CURVES PLATE NOS. IV-3 and IV-3A MAX. ALLOWABLE DISCHARGE FROM BALL MTN. = 4,000 cfs MAX. ALLOWABLE DISCHARGE FROM TOWNSHEND = 7,200 cfs								
	POST OPERATION			(2300 7.5 c.f.s.)	(2900 7.0 c.f.s.)	——	——	——	25.0	27.0	NORMAL SETTING* 3-3-3 | 0-F-0	

*NON FREEZING SEASON

EMERGENCY OPERATION PROCEDURE (E.O.P.)

(to be followed when contact cannot be made with RRS)

BALL MOUNTAIN & TOWNSHEND DAMS

CONDITION 1 (Communication intact between FCDO'S)

The Townshend Operator is responsible for complete closure of gates (min. openings 10 cfs†) at both dams in accordance with the following:

a. Rainfall - 3 inches has fallen in basin

b. Stages -

Location	Ball Mtn.	Townshend
Ball Mtn Pool	40.0'	-
Jamaica	8.0'	-
Townshend Pool	27.0'	27.0'
Newfane	-	8.0'
No. Walpole	-	26.0'

CONDITION 2 (Contact lost between FCDO'S)

Each operator is responsible for complete closure of gates (min. openings 10 cfs) at their respective dams in accordance with the following:

Ball Mountain 3" rainfall or pool stage = 40'

Townshend 3" rainfall or pool stage = 27'

After regulation is made, the Ball Mtn Operator will drive to Townshend Dam to relay all pertinent information.

NOTE: Discharge from reservoir storage is not to be released until contact has been re-established with RRS.

DUTIES DURING EACH PHASE

FLOOD CONTROL DAM OPERATOR (FCDO)

PHASE I
1. Collect & transmit to RRS rainfall and stage data.
2. Operate according to instructions from RRS.

PHASE II
1. Close to minimum settings upon instructions from RRS.
2. Note all unusual conditions at dam, downstream channels, and index stations.
3. Collect & transmit rainfall and stage data at minimum of 3-hr. intervals or as directed by RRS.

PHASE III
1. See Phase II, step 3.
2. Reconnoiter flood plain and note conditions.
3. Report to RRS for further instructions.

PROJECT REGULATOR

PHASE I
1. Compile data.
2. Coordinate next transmission.
3. Restrict outflow to maintain safe channel capacity on West & Conn. Rivers.
4. Inform Basin Regulator of actions.

PHASE II
1. Continue regulation instructions to FCDO.
2. Consult with Basin Regulator to analyze severity of flood.
3. Relay to FCDO any special instructions recommended by Basin Regulator.

PHASE III
1. Collect data from FCDO.
2. Check Guide Curves for allowable releases (Plate Nos. IV-3 and IV-3A)
3. Consult with Basin Regulator.
4. Relay instructions to FCDO.

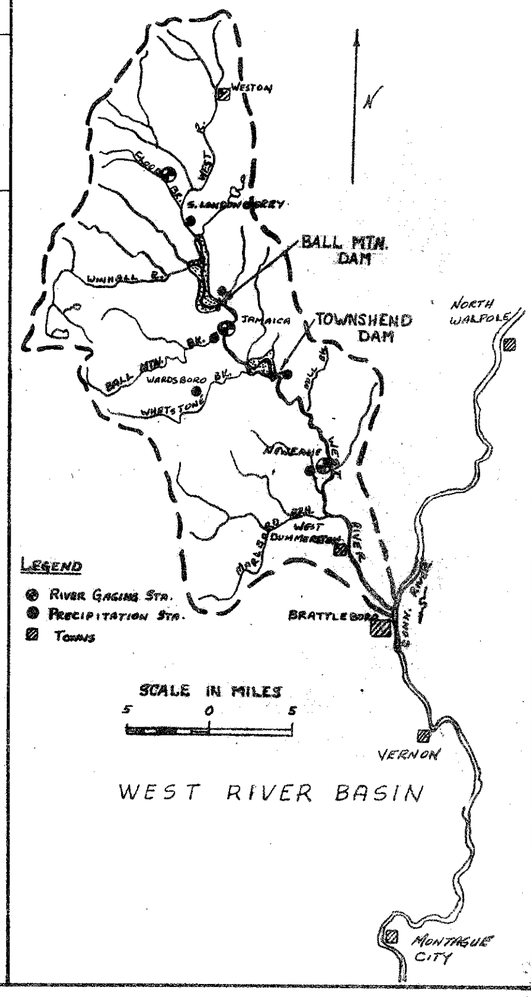
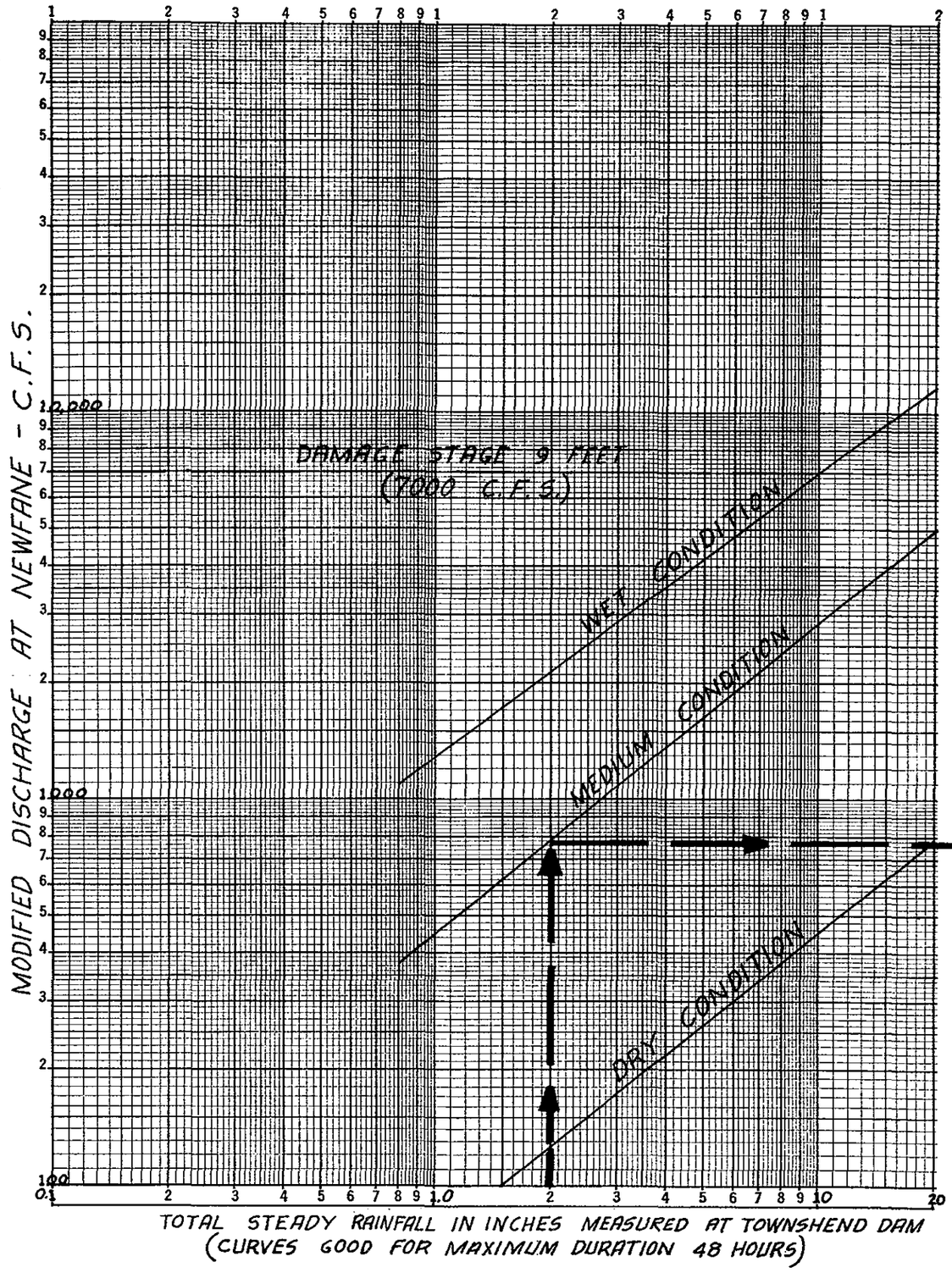


PLATE NO. IV-1


MODIFIED DISCHARGE AT NEWFANE - C.F.S.
10,000
1000
100
DAMAGE STAGE 9 FEET
(7000 C.F.S.)
WET CONDITION
MEDIUM CONDITION
DRY CONDITION
0.1
1.0
10
20
TOTAL STEADY RAINFALL IN INCHES MEASURED AT TOWNSHEND DAM
(CURVES GOOD FOR MAXIMUM DURATION 48 HOURS)

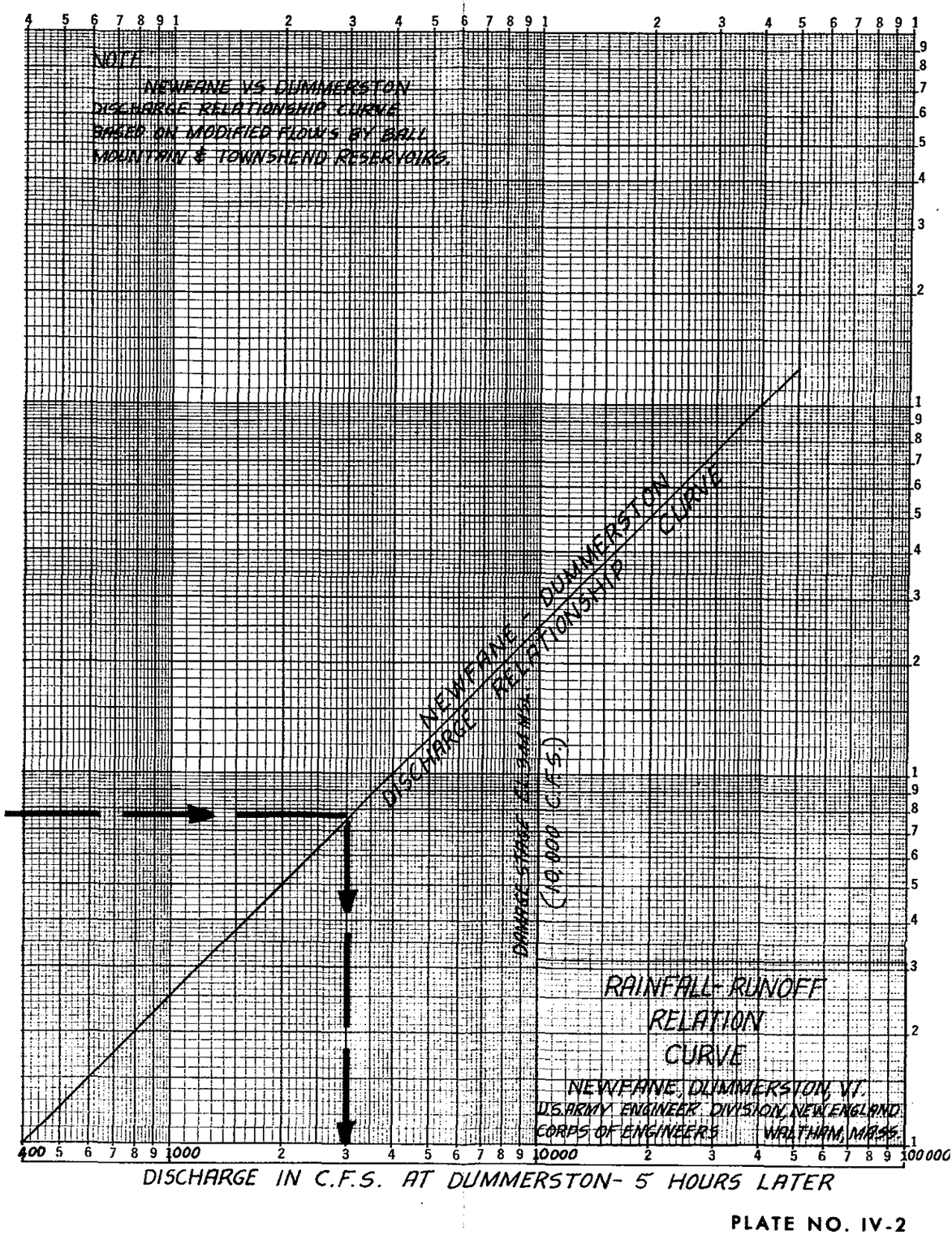

NOTE
NEWFANE VS DUMMERSTON
DISCHARGE RELATIONSHIP CURVE
BASED ON MODIFIED FLOWS BY BALL
MOUNTAIN & TOWNSHEND RESERVOIRS.
DISCHARGE NEWFANE - DUMMERSTON RELATIONSHIP CURVE
DAMAGE STAGE AT DUMMERSTON
(10,000 C.F.S.)
RAINFALL-RUNOFF
RELATION
CURVE
NEWFANE, DUMMERSTON, VT.
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS WALTHAM, MASS.
400
1000
10000
100000
DISCHARGE IN C.F.S. AT DUMMERSTON- 5 HOURS LATER

PLATE NO. IV-2

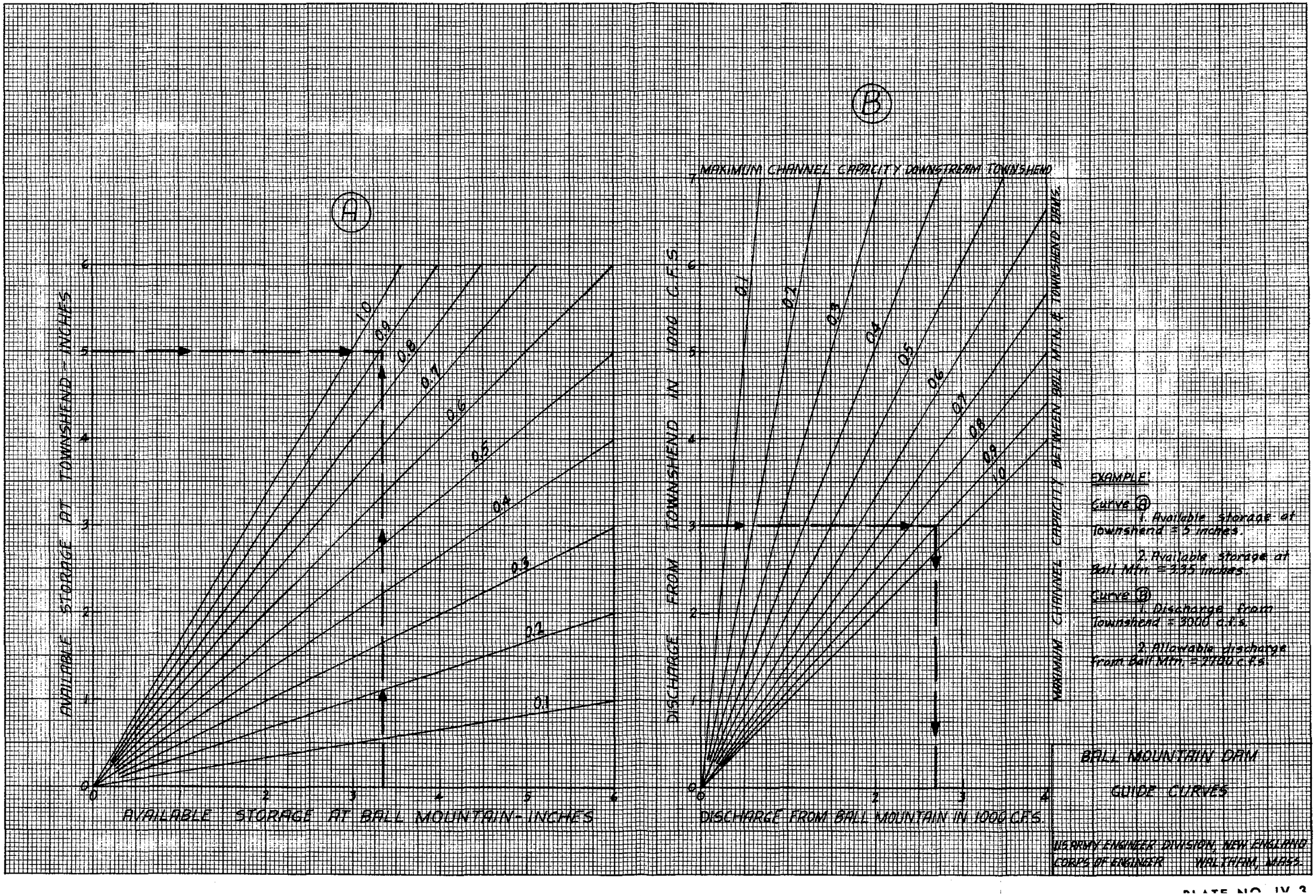


PLATE NO. IV-3

KEUFFEL & ESSER CO. MADE IN U.S.A.

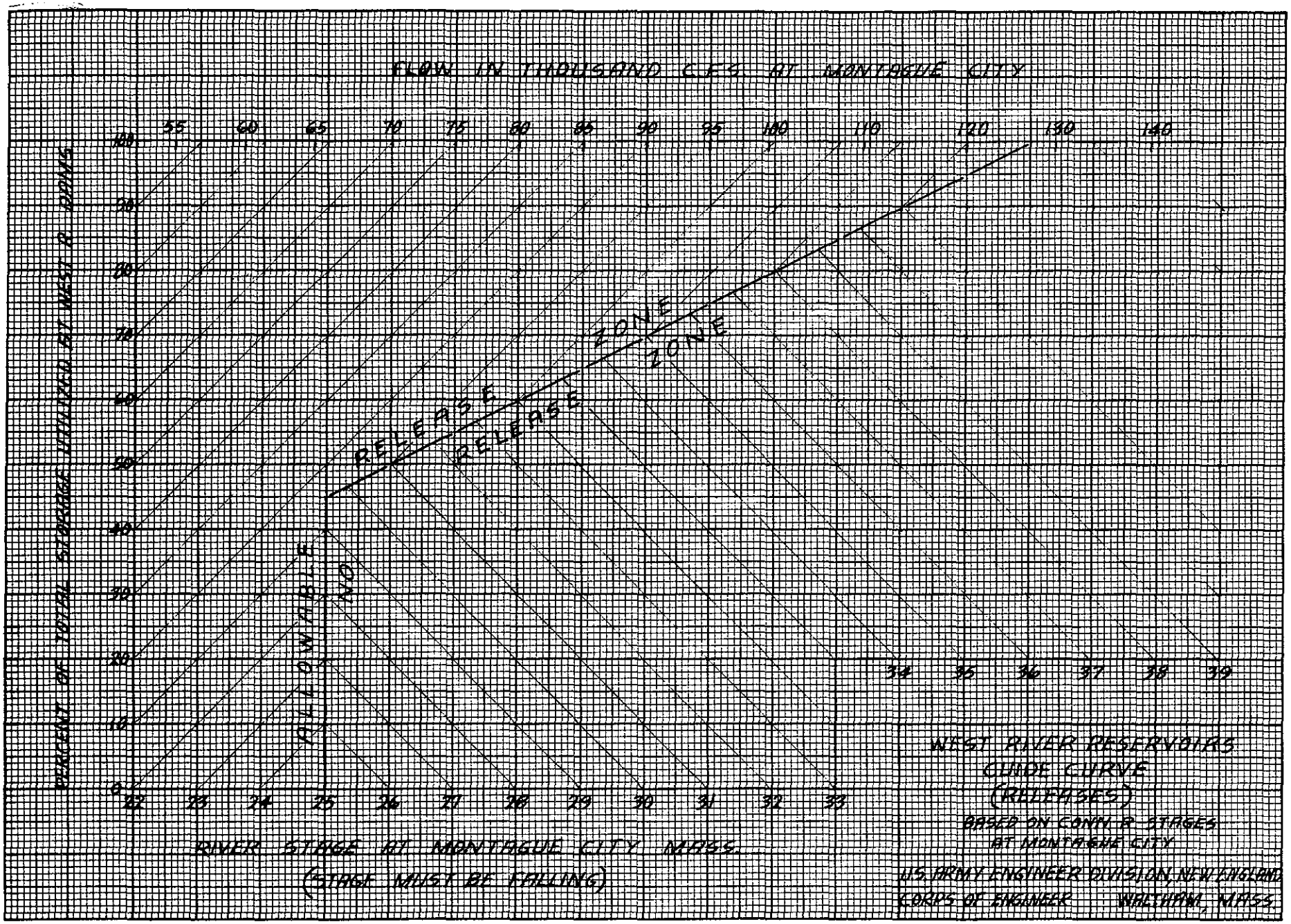


PLATE NO. IV-3A

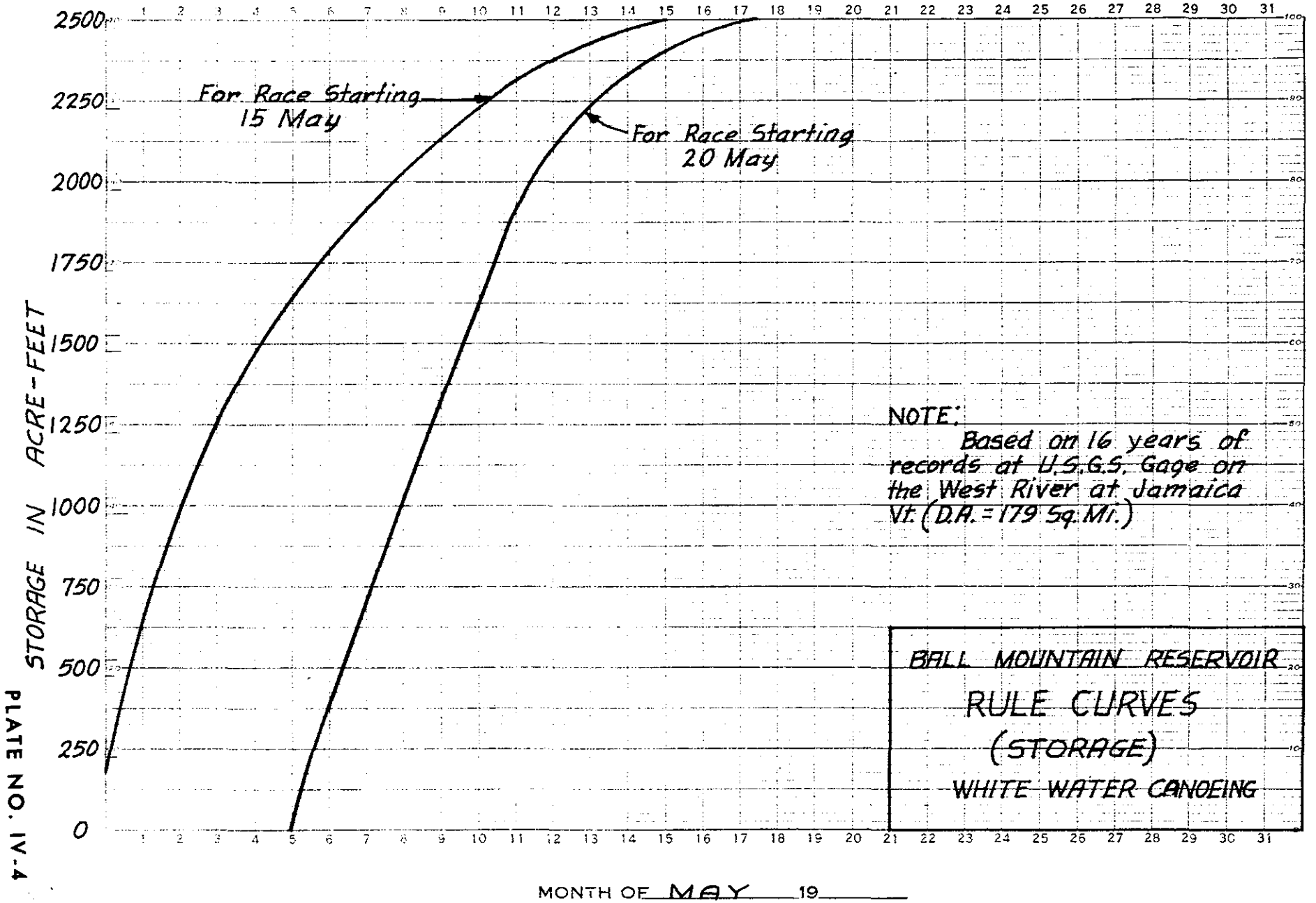

2500
2250
2000
1750
1500
1250
1000
750
500
250
0
STORAGE IN ACRE-FEET
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
For Race Starting
15 May
For Race Starting
20 May
NOTE:
Based on 16 years of records at U.S.G.S. Gage on the West River at Jamaica Vt. (D.A. = 179 Sq. Mi.)
BALL MOUNTAIN RESERVOIR
RULE CURVES
(STORAGE)
WHITE WATER CANOEING
MONTH OF MAY 19

PLATE NO. IV-4

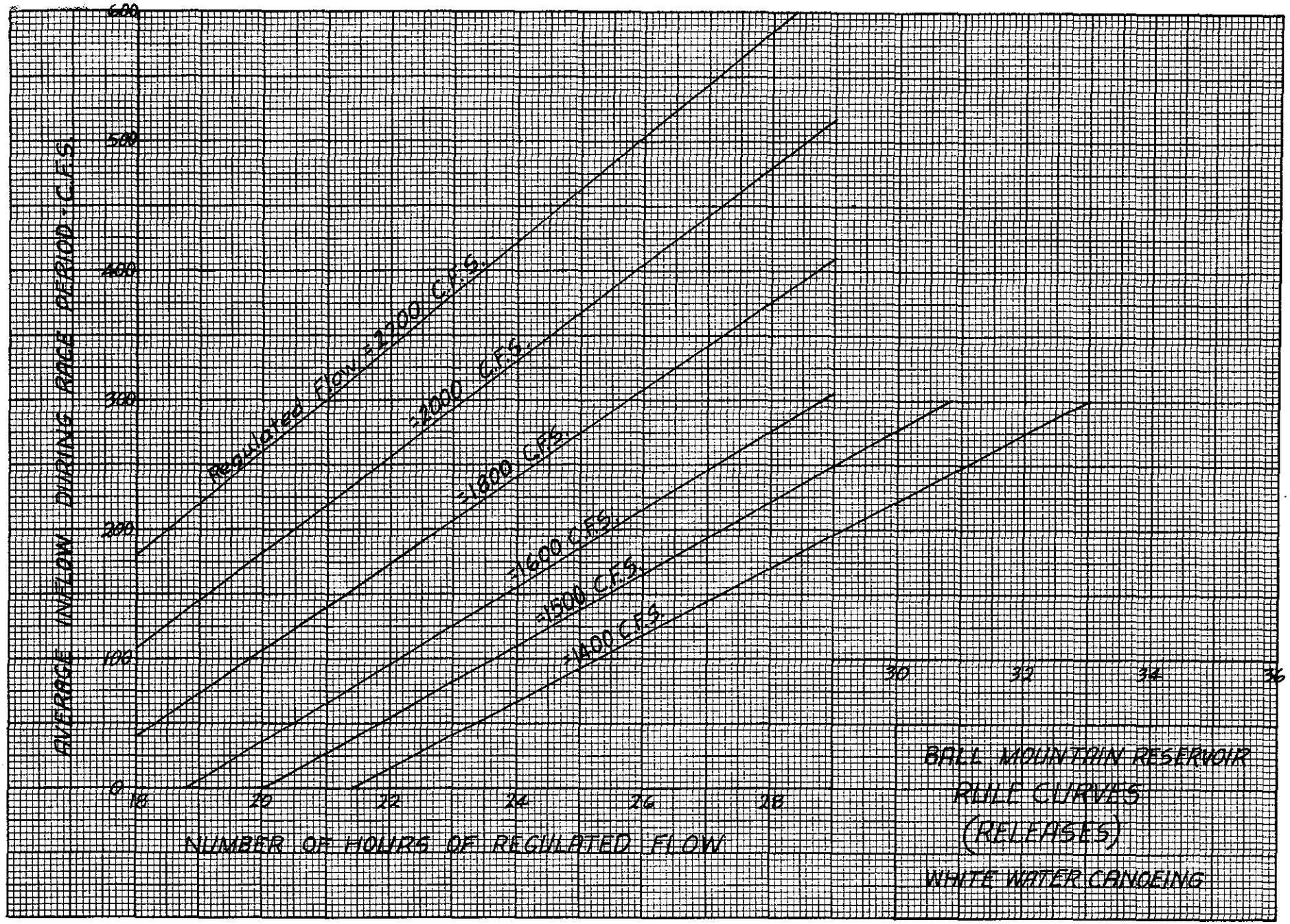

AVERAGE INFLOW DURING RACE PERIOD - C.F.S.
600
500
400
300
200
100
0
10
20
22
24
26
28
30
32
34
36
NUMBER OF HOURS OF REGULATED FLOW
Required Flow = 2200 C.F.S.
=2000 C.F.S.
=1800 C.F.S.
=1600 C.F.S.
=1500 C.F.S.
=1400 C.F.S.
BALL MOUNTAIN RESERVOIR
RULE CURVES
(RELEASES)
WHITE WATER CANOEING

PLATE NO. IV-5

AREA IN HUNDRED ACRES

AREA

CAPACITY

SPILLWAY CREST ELEV. 1070 M.S.L.

CREST ELEV. 1070 M.S.L.

810 ACRES

54,600 ACRE FEET

DRAINAGE AREA = 122 SM.
1" RUNOFF = 3180 AC. FT.

HEIGHT ABOVE INVERT IN FEET

STORAGE IN INCHES

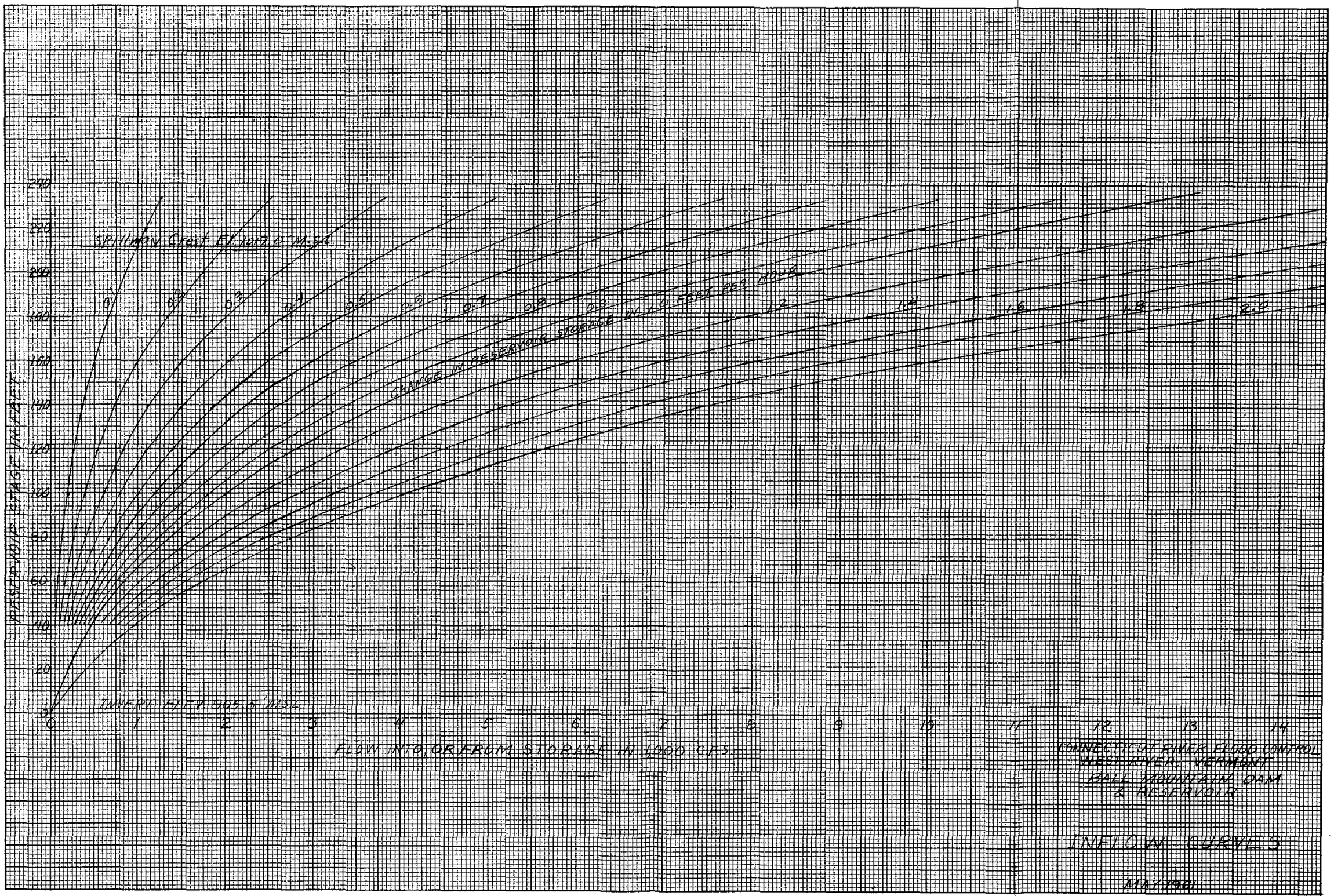
INVERT ELEV. 965.5' M.S.L.

CAPACITY IN THOUSAND ACRE-FEET

CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
BALL MOUNTAIN RESERVOIR
AREA & CAPACITY CURVES
MAY 1950

PLATE NO. IV-6

359-11L
MADE IN U.S.A.
10 X 10 TO THE ½ INCH
KEUFFEL & ESSER CO.

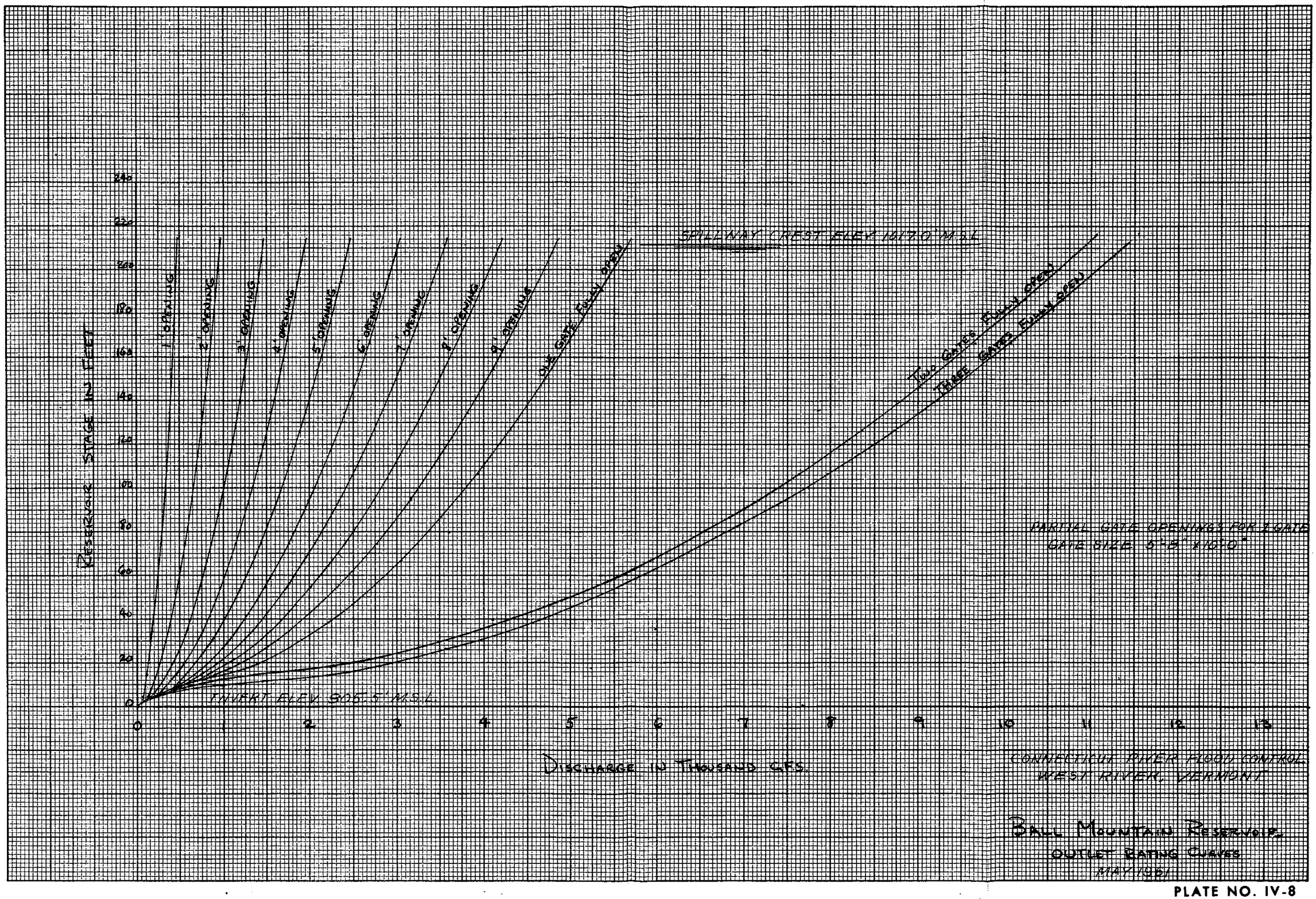


CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
ROLLE MOUNTAIN DAM
& RESERVOIR

INFLOW CURVES

MAY 1960

PLATE NO. IV-7

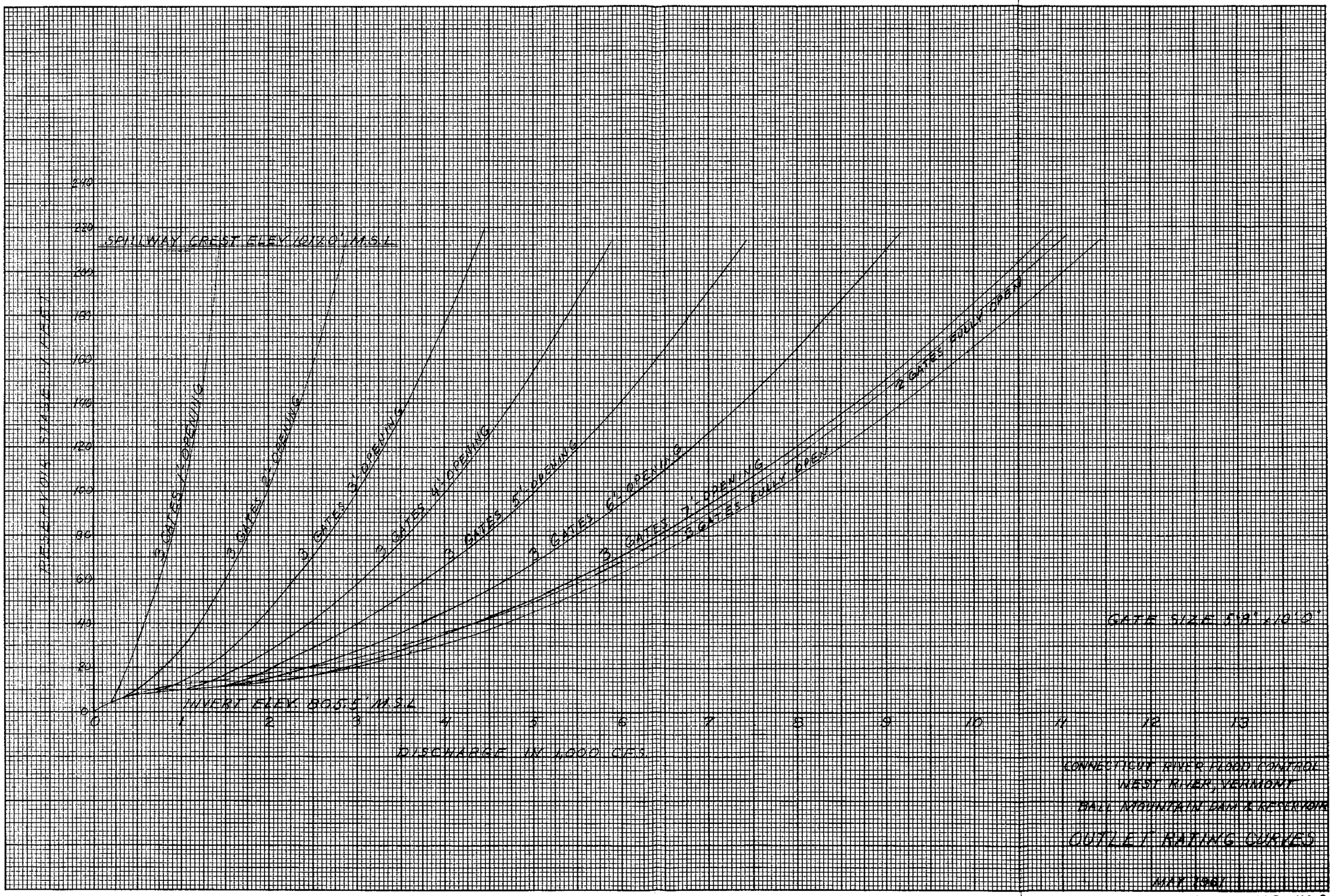


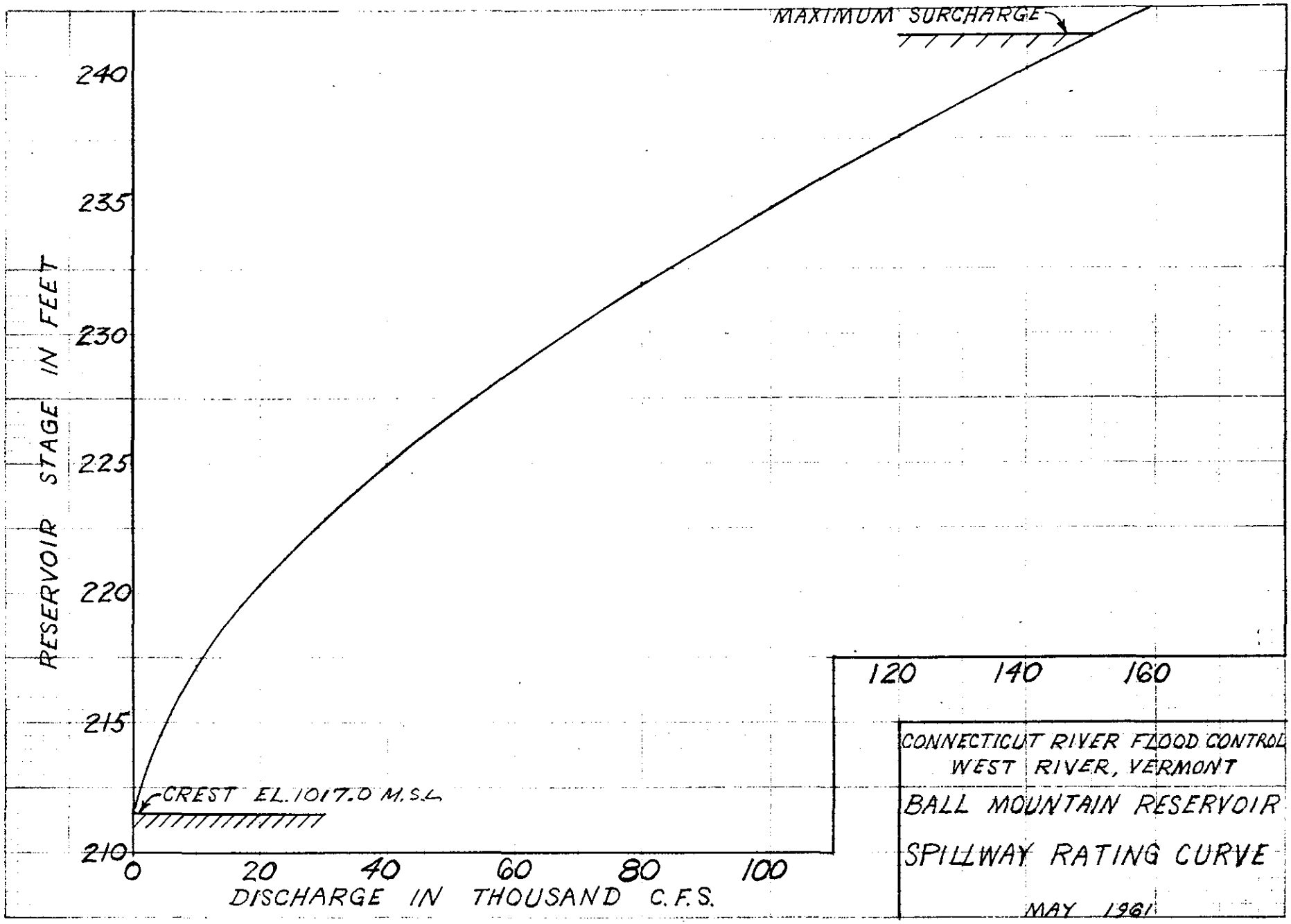
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT

BALL MOUNTAIN RESERVOIR
OUTLET RATING CURVES
MAY 1960

PLATE NO. IV-8

10 X 10 TO THE ½ INCH
KEUFFEL & ESSER CO.
359-11L
MADE IN U.S.A.


SPILLWAY CREST ELEV. 1020.0' M.S.L.
INVERT ELEV. 805.5' M.S.L.
ELEVATION IN FEET M.S.L.
DISCHARGE IN 1,000 CFS.
GATE SIZE 5'0" x 10'0"
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
BALL MOUNTAIN DAM & RESERVOIR
OUTLET RATING CURVES
MAY 1961
PLATE NO. IV-9



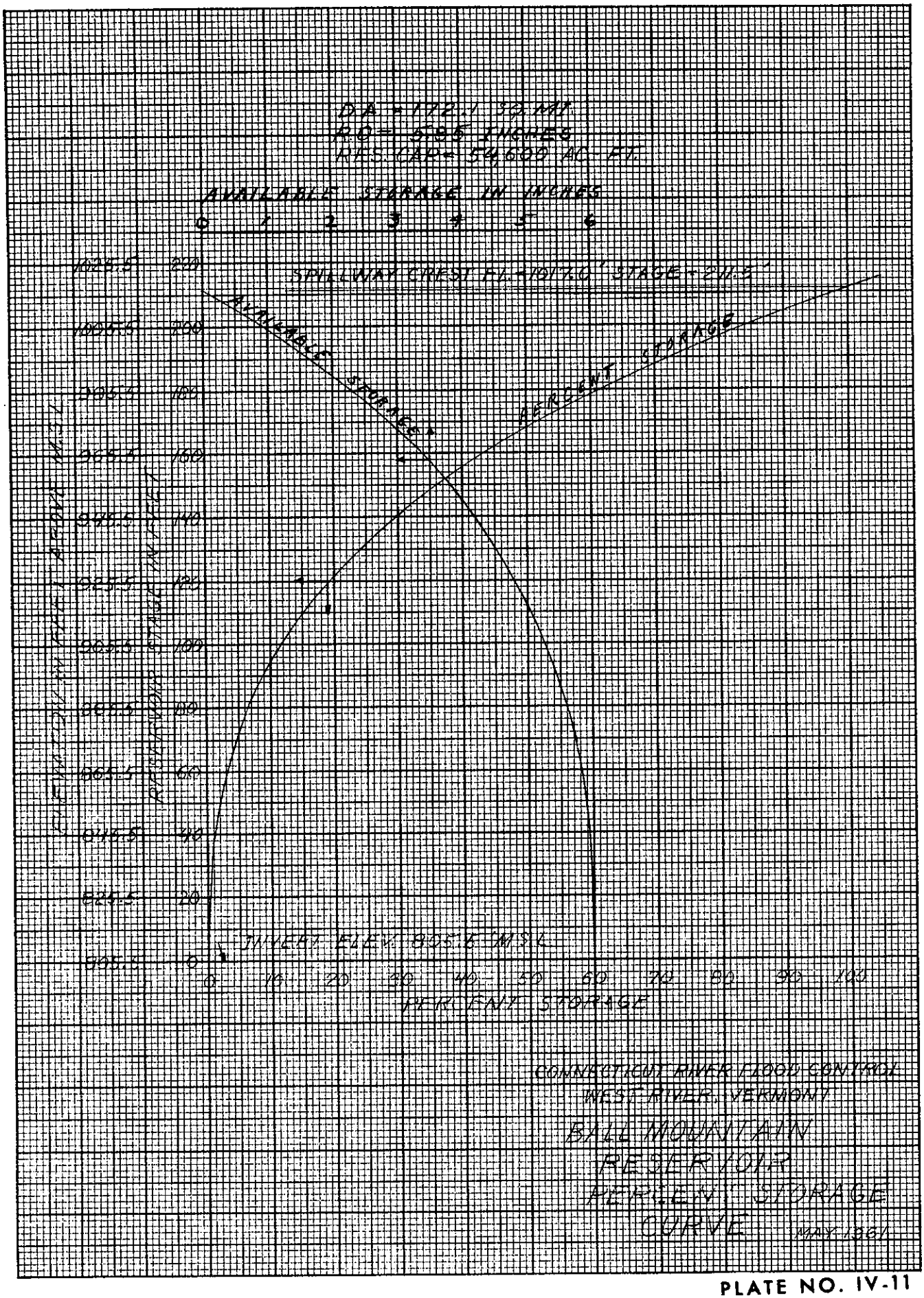
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT

BALL MOUNTAIN RESERVOIR

SPILLWAY RATING CURVE

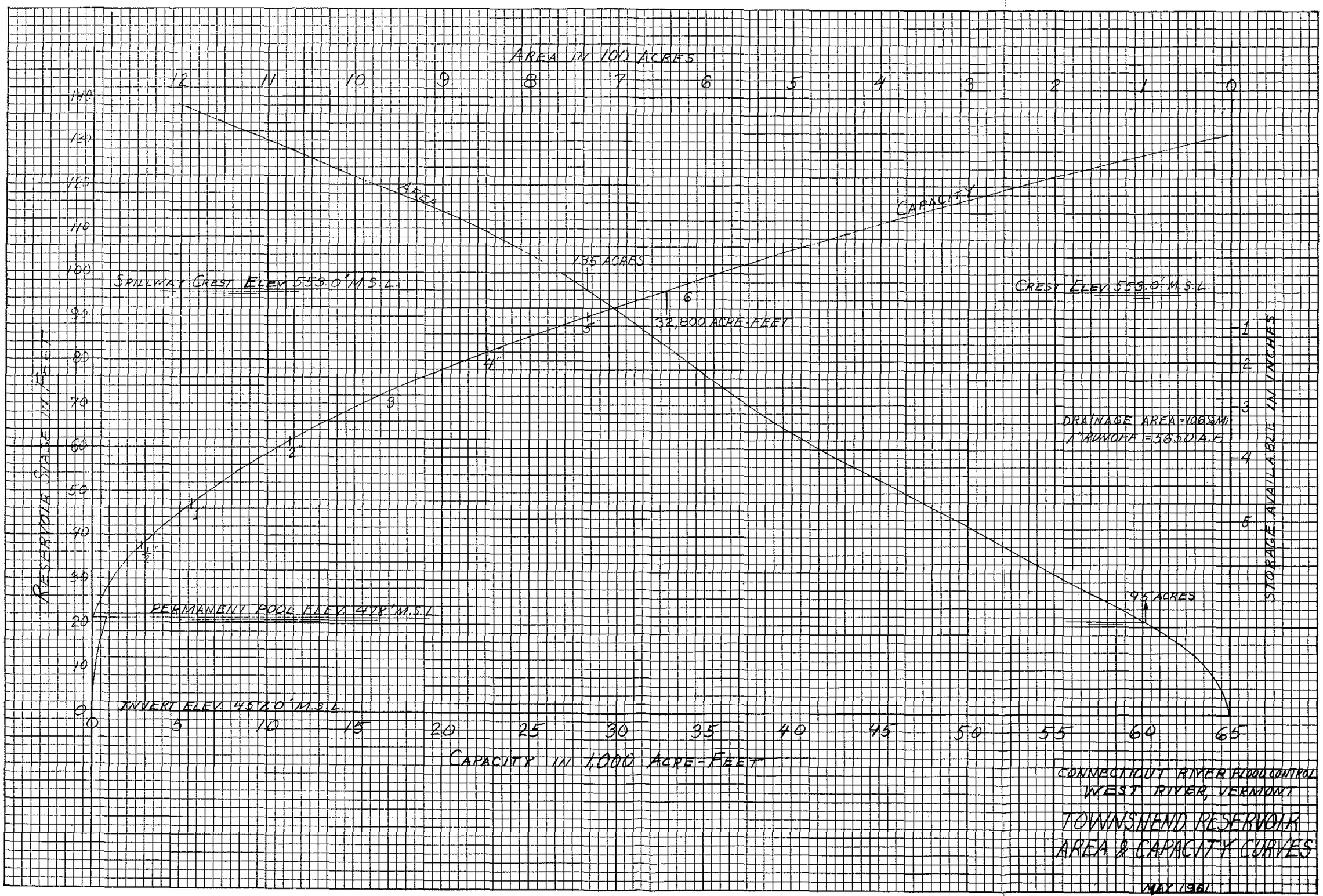
MAY 1961

PLATE NO. IV-10



CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
BALL MOUNTAIN
RESERVOIR
AVERAGE STORAGE
CURVE MAY 1961

PLATE NO. IV-11



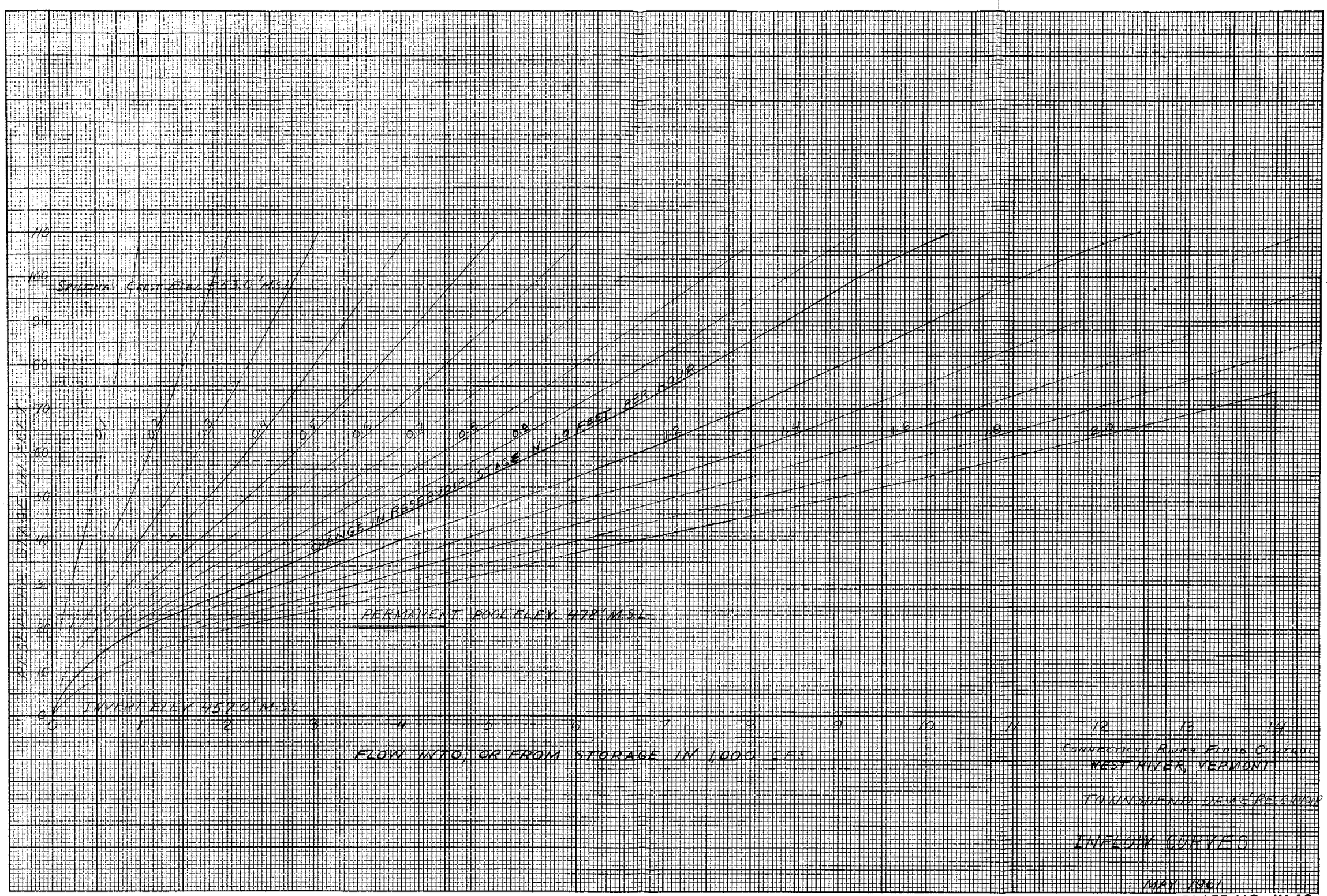
KEUFFEL & ESSER CO. MADE IN U.S.A.

CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT

TOWNSHEND RESERVOIR AREA & CAPACITY CURVES

MAY 1961

PLATE NO. IV-12



KEUFFEL & ESSER CO.

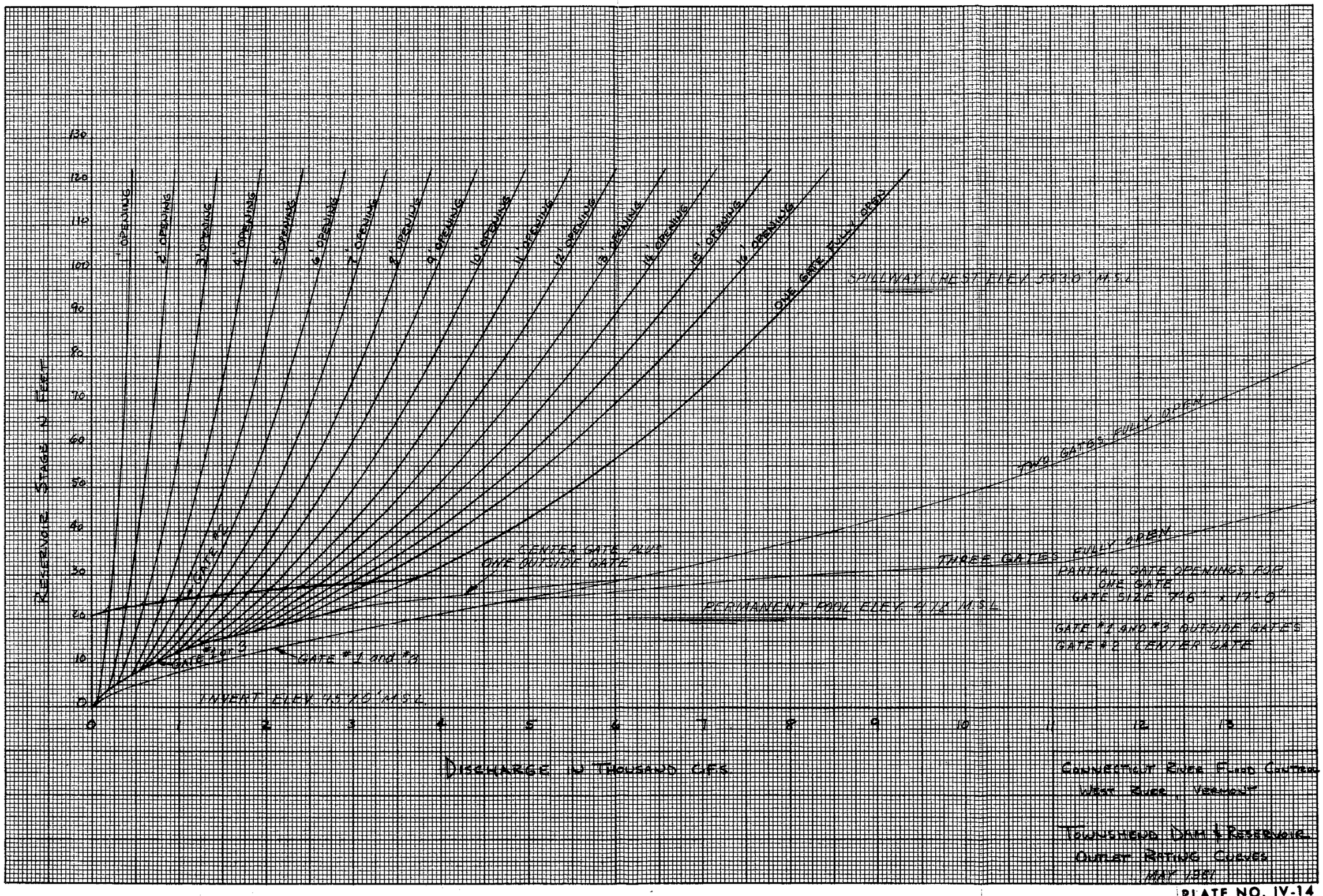
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
TOWNSHEND DAM & RESERVOIR

INFLOW CURVES

MAY 1961

PLATE NO. IV-13

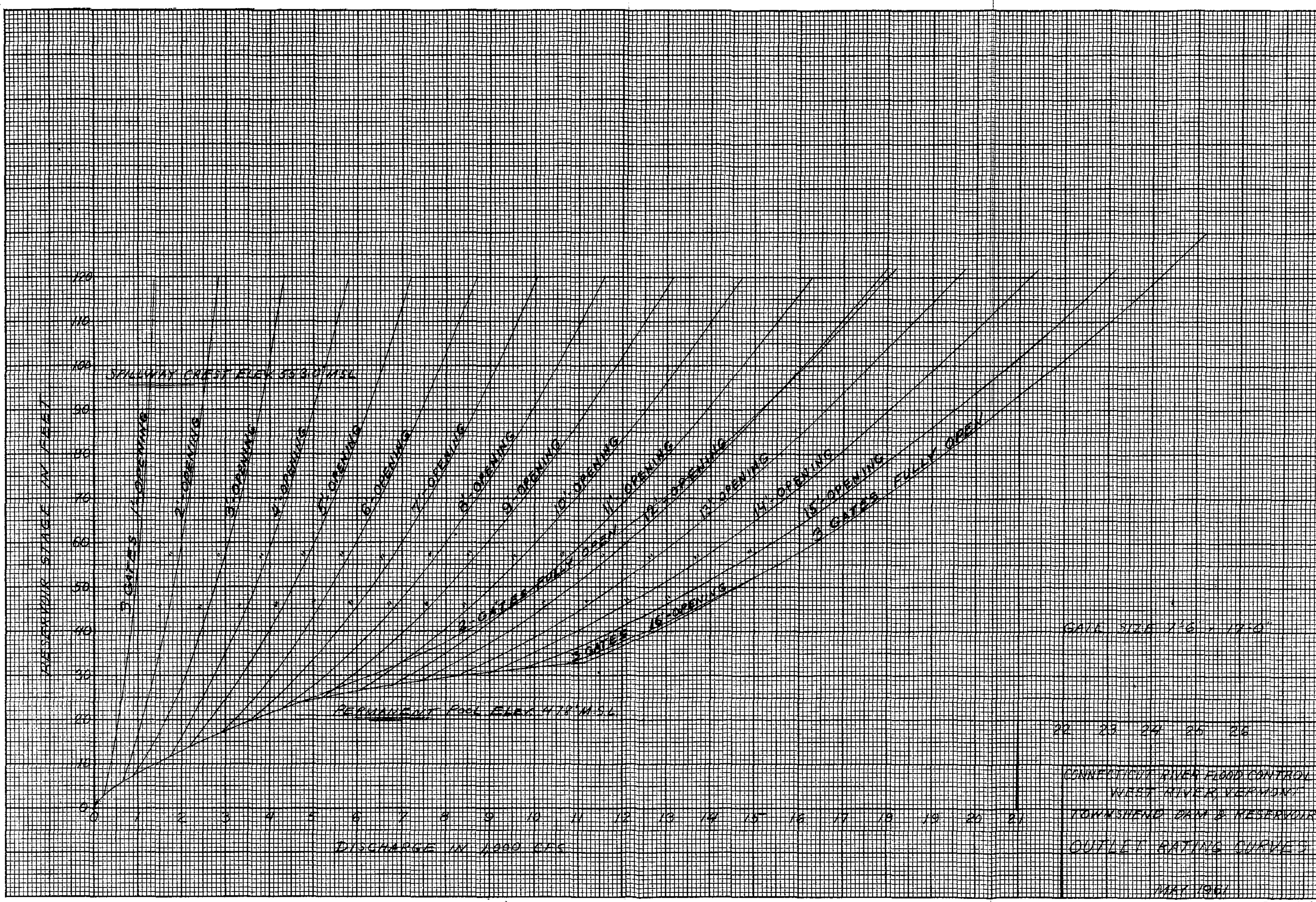
K&E 10 X 10 TO THE ½ INCH 359-11L
KEUFFEL & ESSER CO. MADE IN U.S.A.



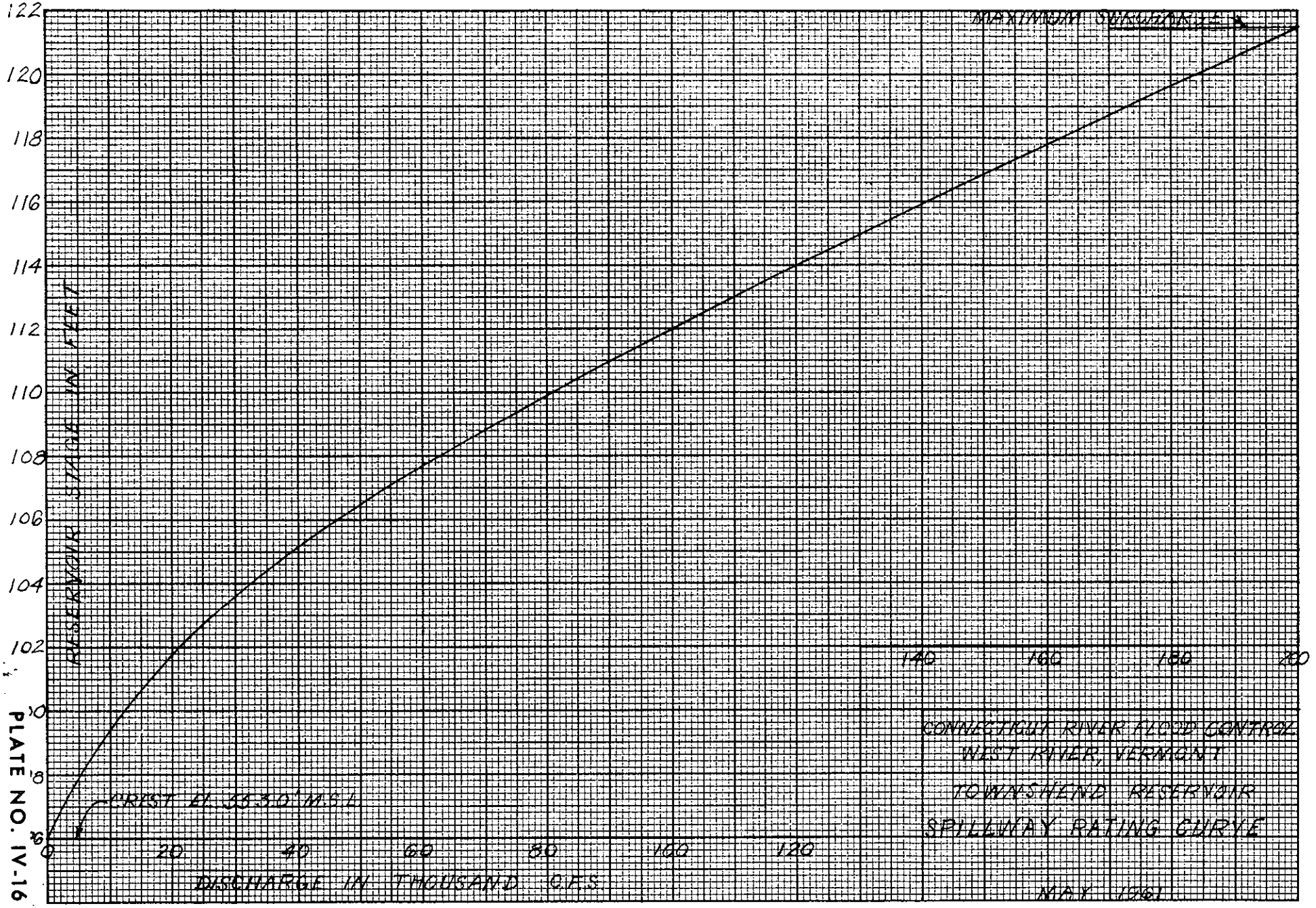
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT

TOWNSHEND DAM & RESERVOIR
OUTLET RATING CURVES
MAY 1956

PLATE NO. IV-14

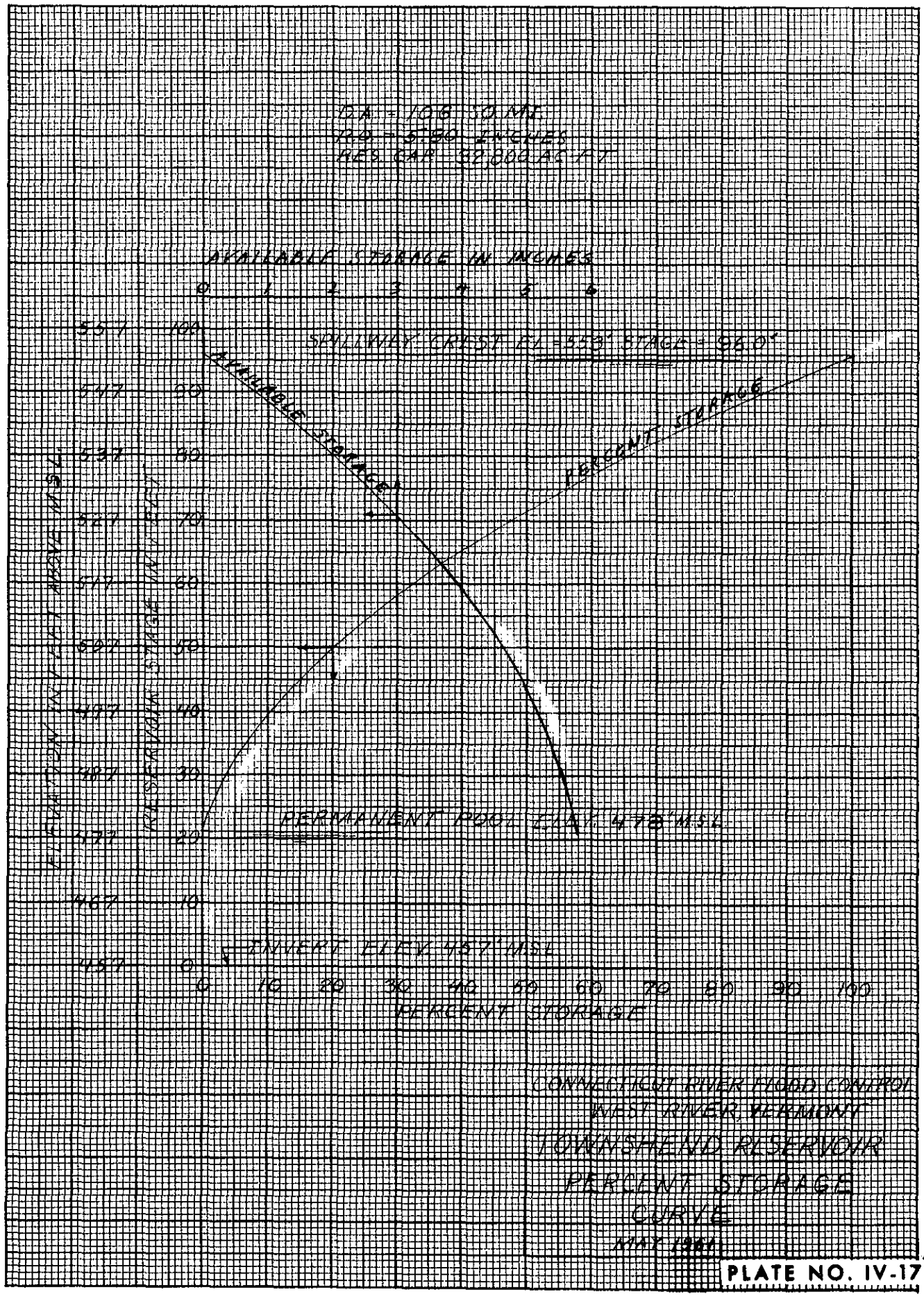

SPILLWAY CREST ELEV. 553.0' MSL
PERMANENT POOL ELEV. 478' MSL
RESERVOIR STAGE IN FEET
DISCHARGE IN 1000 CFS
3 GATES 1' OPENING
2' OPENING
3' OPENING
4' OPENING
5' OPENING
6' OPENING
7' OPENING
8' OPENING
9' OPENING
10' OPENING
11' OPENING
12' OPENING
13' OPENING
14' OPENING
15' OPENING
3 GATES 16' OPENING
3 GATES FULLY OPEN
2 GATES FULLY OPEN
GATE SIZE 7'6" x 17'0"
CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER VERMONT
TOWNSHEND DAM & RESERVOIR
OUTLET RATING CURVES
MAY 1961

KEUFFEL & ESSER CO. MADE IN U.S.A.



CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
TOWNSHEND RESERVOIR
SPILLWAY RATING CURVE
MAY 1961

PLATE NO. IV-16



CONNECTICUT RIVER FLOOD CONTROL
WEST RIVER, VERMONT
TOWNSHEND RESERVOIR
PERCENT STORAGE
CURVE
MAY 1961

PLATE NO. IV-17

A T T A C H M E N T V

OPERATIONAL PROCEDURES AND MAINTENANCE

OF

HYDROLOGIC EQUIPMENT

AT

BALL MOUNTAIN AND TOWNSHEND RESERVOIRS

ATTACHMENT V

TABLE OF CONTENTS

ATTACHMENT V
OPERATIONAL PROCEDURES
AND MAINTENANCE OF
HYDROLOGIC EQUIPMENT

1. PRECIPITATION GAGE

An automatic recording precipitation gage is installed at Ball Mountain and Townshend Dams which continuously records official precipitation readings for the U. S. Weather Bureau (USWB). The Flood Control Dam Operator (FCDO) should read the USWB rain gage daily and record the observations on WB Forms 1009-R and 612-24. While reading the gage, the operator should inspect the equipment to see if the clock is running correctly and the pen inking properly. Unless precipitation is falling at the time of observation, the pen of the recording gage should be raised to the next 0.25" line to avoid overlapping of the record. Rain gage charts (WB Form 1028c) should be changed each Monday and forwarded with WB Form 1009-R to the Reservoir Regulation Section (RRS). If additional charts, forms or other USWB supplies are needed, the FCDO should note it on the submitted WB Form 1009-R. Instructions on correct operation of precipitation gages and recording data are printed on the covers of each pad of USWB forms.

A Weather Bureau representative visits the dam several times each year to service the precipitation gage. Should a malfunction of the gage occur between visits, the FCDO should notify the RRS who will make arrangements with the USWB to repair the gage.

2. THERMOMETER

A maximum-minimum thermometer is located at the dam. The FCDO should adjust the maximum and minimum temperature levels daily. Whenever temperature data are requested by the RRS this information is transmitted via the NED radio network.

3. RESERVOIR STAGE RECORDER

The automatic water level recorders at Ball Mountain and Townshend Dams trace the water level in the reservoirs at all times. The water-stage recorder is operated by a float. The recording instrument should be checked each morning to assure that the clock is

keeping correct time and that the pen is tracing properly. Any discrepancies in the record as evidenced by the pen time or gage height, should be noted on the chart and the instrument reset. During periods of reservoir storage, the outside tile or staff gage should be read to check the tape readings and chart record. The chart record should be changed the first working day of each month. At the beginning and ending of each monthly chart, the following information should be noted in ink on the chart.

a. Outside (tile) gage reading

b. Pen gage height reading

c. Watch time

d. Pen time

e. Date and name of dam

New charts for monthly recorders should be obtained from the NED warehouse.

4. TELEPHONE TRANSMITTER (TELEMARK)

A telephone transmitter (telemark) is in operation on the West River at Newfane to obtain river stages to aid in regulating Townshend Dam. Presently telemarks are the most satisfactory method of river stage reporting, especially where it is essential to have 24-hour coverage of the index stations. Should the telemark become inoperative, the FCDO should visit the USGS gage to ascertain where the difficulty is. If the trouble cannot be determined at the gage, the telephone company should be requested to check out their circuits. The FCDO should be at the gage when the telephone company inspects their system. If the telemark still cannot be made operative, the RRS should be notified and NED and/or USGS personnel will inspect the telemark system.

5. TAILWATER GAGING STATION

A tailwater gaging station is located downstream of the dam to provide a continuous official record of the discharge from the dam. It is essential that the equipment be checked frequently to assure a continuous record. The tailwater gage readings included in the routine radio and telephone reports to the RRS on Fridays are used

for calibration of the gates and as a ready reference of basin run-off conditions at the time of observation. Since it is necessary to drive some distance to the gage, it is suggested that inspections and readings of the remote gage be made at a convenient time on Thursday and the gage reading be included in the Friday report.

If inspection of the gage indicates a need for repair, the RRS should be notified immediately and arrangements will be made with the USGS to have the equipment repaired.

6. SNOW SAMPLING SET

A snow sampling set has been assigned to the FCDO. Procedures for obtaining snow survey data should follow instructions set forth in Snow-Survey Sampling Guide, Department of Agriculture Handbook No. 169. If given proper care, the only maintenance required would be occasional replacement of worn-out cutter heads.